BROWN BAST

A. R. SANDERSON, F.L.S.

H. SUTCLIFFE, A.R.C.Sc., F.R.M.S.

THE RUBBER
GROWERS' ASSOCIATION

BROWN BAST

An Investigation
into
Its Causes and Methods of Treatment

BY

A. R. SANDERSON, F.L.S.

AND

H. SUTCLIFFE, A.R.C.Sc., F.R.M.S.

Mycologists to the Rubber Growers' Association
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PREFACE.

A FULL description of the bark and cortex of the Rubber tree affected with "Brown Bast Disease" will be found in the following pages. From this description Managers and Assistants should be able to identify cortices and barks which are affected with the "disease."

The diagnosis should be comparatively easy, after one or two typical cases have been carefully examined, especially in the case of trees which show the "disease" in the middle or later stages. The real difficulty lies in diagnosing the "disease" in the very earliest stages, but the very fact that a tree has ceased to yield latex should be a sufficient indication that the cortex may be affected by the "disease," although the typical symptoms may not be present at that time. Such doubtful trees should be marked in a special way with a view to future re-examination.

In some cases it may be found that the state of "dryness" is only temporary, in other cases the "dryness" may be found more or less permanent, the typical symptoms of "Brown Bast" only developing much later. When, however, the undoubted characteristic signs do appear, the work of "stripping" the affected tissues from the tree should be put in hand as soon as possible. Any delay in this respect only adds to the difficulty and cost of the treatment.

As far as possible, in reading the report for the first time, attention should be directed to the chapters dealing with the description of the "disease" and methods of treatment. The pages dealing with the cause being mainly of theoretical interest may well be left for future reading.

It may be pointed out that in the report, special emphasis has been laid on the early treatment of the diseased tissue, and that this is essential if large areas of bark and cortex are

to be prevented from becoming useless as a future source of revenue owing to the formation of "burrs" and "nodules."

In the chapters dealing with the cause of "Brown Bast" the theory advanced is that the "disease" is physiological, and is due to the operation of tapping. Further investigation, however, is required in this connection in order to clear up several obscure points, especially the relationship between the frequency of tapping and the incidence of the "disease," together with more information as to the length of time between the formation of meristem and the cessation of the flow of latex.

The book contains an Appendix on "dry" trees, in which the details and significance of the incidence of this symptom are considered.

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CONTENTS.

INTRODUCTION.

THIS book gives a complete description of Brown Bast tissue, and contains in addition the results of field observations in many parts of the Malay Peninsula, Ceylon, and India.

From what has been revealed by microscopic examination and from general field observation, we submit a theory for the cause of the "disease."

Our conclusion as to the cause being physiological has been arrived at after due consideration of all the present known facts. The idea of the "disease" being physiological in origin is by no means new, though the physiological theory advanced in the present paper is new. The treatment advocated is put forward as curative in effect and the simplest in operation at least cost, and it is based on sound practice.

The estates quoted are not the only ones where successful treatment has been carried out, but they are sufficient to show what can and should be done.

Some estate managers are against the form of treatment recommended, either because it means the removal of valuable cortical tissue, it is too costly, requires labour where that is already scarce, is too drastic, requires supervision, they have more trees than required so can thin out, or, finally, because they do not wish to do anything.

We hope that at least the present paper will convince Estate Managers that the work can and must be done, and with ordinary care success in treatment is assured.

INVESTIGATION OF BROWN BAST TISSUE.

Typical cases of Brown Bast on eight-year-old trees were chosen, after careful examination. Small portions of cortex were cut out, three pieces from each position, fixed one each in picro-formal, chrome-acetic acid, acetic alcohol. Fresh tissue was also examined from the same trees, the specimens being similar to those fixed.

In all the cases dealt with below the trees had been taken out of tapping for some little time owing to Brown Bast. Previous to becoming dry, all had yielded a normal amount of latex as compared with surrounding trees not affected with Brown Bast.

The material in every case was fixed on the spot immediately on removal.

A. Tree eight years old. Tapping commenced in April, 1916. The affected cuts were opened October, 1916, and April, 1917. The tree was tapped on half-spiral, and changed over each six months.

The disease had passed over to the new cut and slightly upwards into renewed bark, large nodular masses had formed low down the stem below 20 inches from the ground level; this nodular formation was extending upwards and laterally. The specimens were taken from a part 20 inches above ground level.

B. Tree eight years old, planted at the same time as "A." Tapping as "A."

This was a comparatively recent case—under four months from first being diagnosed.

The specimens taken included the cut and portions of renewed bark, and included also the point where the Brown Bast tissue ran out into normal tissue upwards.

C. Specimens were taken from a lateral root of "B" tree beyond the point where diseased tissue was sandwiched between layers of normal latex bearing tissue. The disease was apparent all round the tree, and

brought to a point on the upper side some two feet above the collar.

D. Tree eight years old. Tapping as "A." The attack had progressed for one year, apparently starting below the cut opened October, 1918, which was on a side previously tapped. Tapping was stopped in June, 1919, when the tree ran dry. The nodular stage was commencing.

Ridges were in process of formation on the tapped surface, and prominences were observed on the under surface of the stripped cortex.

E. Nodular specimen from "D."

F. Normal cortex from tree eight years old similar to above and from the same area.

In addition to the foregoing many specimens from older and younger trees were examined from time to time; details of some of these are described.

Symptoms of the Disease.

Usually one of the earliest indications of the presence of Brown Bast is the difficulty of obtaining latex by the usual depth of tapping. When the depth of tapping has to be increased in order to obtain latex Brown Bast may be suspected. A portion of the cut may continue to yield latex in the normal manner. The deeper layers of the cortex may still continue to yield latex, but later the flow of latex ceases or is much reduced, and the tree is termed "dry," *i.e.*, the disease, if present, has penetrated to deeper layers of cortex which were previously free.

All "dry" trees, however, are not affected with Brown Bast, and from the preceding it is evident that all Brown Bast trees do not necessarily become "dry." A portion only of one ring of latex vessels may be affected which would not materially affect the yield. If the disease does not penetrate to the deeper layers somewhat quickly, it is possible that in some cases much of the area of cortex in which the Brown Bast occurs not very deeply seated, may be removed during tapping operations, and later a normal flow of latex is obtained by the ordinary depth of tapping, due to the fact that normal cortex has been reached. This is not recommended as a method of treatment.

It is not likely that all Brown Bast affected cortex will be removed by tapping, and what remains is usually quite suffi-

cient, some time later on, it may be when the cut is finished, to continue the spread of the disease both laterally and in depth. When such a section is re-opened, *i.e.*, the section is again brought into tapping, Brown Bast is found at once, and at a greater depth in the cortex.

If so-called "dry" trees are rested for some time (two months), and when tapping is re-commenced they are still dry, Brown Bast is probably present. The cortex below the cut should be examined to see if the typical discoloration is apparent.

Brown Bast cortex has a dark brown, greenish brown, or olive appearance when scraped or cut into with the tapping knife. In advanced cases, especially on old trees, the diseased cortex is frequently watery.

The more seriously affected areas are sharply defined by the difference in colour of the cortical tissue, as compared with normal cortex.

The outer bark is frequently characterised by long or short, longitudinal splits or cracks, a preliminary to scaling off (Plate 2). This is more usual when the disease is from two feet above ground level to the collar and is spreading downwards. Such cracks are most frequent from a point just above the collar (below an old cut), spreading along a lateral root.

Correct diagnosis in the earliest stages is a matter of extreme difficulty, and this largely nullifies the importance of figures for Brown Bast obtained by coolies, etc. This applies with still greater force to cases notified by Chinese contract tappers.

Examination of fresh tissue "A," "C," "D," disclosed the presence of large numbers of globules, which varied much in size, though they were fairly regular in shape. These globules were slightly more numerous in the vicinity of the medullary rays. Two were observed to coalesce. These globules are frequently, but not constantly, present in Brown Bast cortex, and we have not seen them in normal cortex.

Tests were made to determine the chemical nature of these bodies.

1. Sections were irrigated with dilute caustic soda. The globules immediately disappeared—dissolved in the soda. This was done repeatedly with fresh sections and always with the same result.

   On one occasion, when using a very dilute solution

of caustic soda, the globules were observed to dissolve slowly, commencing from the side nearest the point of entry of the soda.

2. Sections which had been examined and contained large numbers of globules in the cells were immersed for 24 hours in ether. Controls were similarly immersed in weak formaline.

   On examining the sections from the ether no trace of the globules could be found. Those sections from the formaline still contained the globules, hence disappearance from those in the ether was not due merely to mechanical action.

3. Treatment with alcohol is almost without action on the globules. They do not stain with Sudan III., but absorb gentian violet and also azoblue to a slight extent.

4. So far we have been unable to find these globules of oil or fatty matter in normal cortex.

5. Globules which reacted similarly to those present in Brown Bast tissue have been noticed by the writers in cortex attacked by Sphæronema sp. (Mouldy Rot of the tapped surface). In such tissues the globules were present in much greater proportion than in Brown Bast tissue.

Belgrave has also noted the presence of these globules in Brown Bast tissue, and considers they may be one of the difficultly soluble organic acids, *e.g.*, isobutyric or isovaleric, and states further that the cells containing them are often those of which the cell walls have the curious injected-with-latex appearance characteristic of Brown Bast.

In our own investigation we found these globules fairly evenly distributed throughout affected tissues.

These experiments led us at the time to think that the presence of the globules in conjunction with the absence of starch suggested :—

(*a*) That the starch may have been broken down by some enzyme and an oil formed ;

or

(*b*) That owing to some metabolic change due to physiological causes the oil in Brown Bast tissues is formed in place of starch.

Brown Bast Cortex:—

I.—Starch is usually absent, or present only in very small quantities, depending perhaps on the stage of the disease, *i.e.*, on the length of time the disease has been developing. When the original incidence of Brown Bast, however, is deep-seated and has not spread outwards, we have noticed that starch is present in quantity comparable to normal cortex in those areas of cortex to the outside of the affected portions. The distribution of the starch, size of grain, etc., are similar in that case to what obtains in normal cortex. In two specimens examined starch was present in abundance (very small grains), comparable to what one sees in normal cortex, and was not confined largely to medullary ray cells, but was fairly regularly distributed. Passing inwards, the proportion of starch increased to a point less than 1 mm. from the cambium, *i.e.*, in a region of the cortex where the sieve tubes still functioned as such, the cells lying alongside the sieve tubes were in some cases quite full of small starch grains. The maximum amount was present from this point to a point just outside the zone where the sieve tubes as such lost their identity, *i.e.*, where the sieve plates could not be made out. In both these cases very early stages of Brown Bast were evident at a point more than 2·5 mm. from the inner surface of the cortex. No starch was present in that portion of the cortex external to the Brown Bast zone.

II.—Oil globules are frequently present, sometimes in considerable quantities. Some at least of this may be only a substitution product for starch formed under peculiar conditions, or it may be the result of the breaking down of the starch.

III.—A brown substance similar to tannin is abundant, many of the cells being entirely filled with this substance, and others have the walls discoloured with it. There is, however, not a very excessive amount present in the outer cortex as compared with normal cortex, and this in itself cannot be considered as distinctive of Brown Bast. Tannins are abundant even in normal cortex, more especially in the outer portions, but in Brown Bast cortex the abundance of tannin is apparent at much greater depths, and when deep-seated is characteristic. Possibly some portion of the tannin in Brown Bast cortex may be formed as a by-product of metabolism, under conditions such that respiration is imperfect. Deep-seated excess of tannin is frequently accompanied by an excessive amount of

moisture,—a water-logged condition of the bark. In old cases, as noticed occasionally when stripping, the wood beneath is discoloured, due to the presence of tannins, and such may be regarded as a natural result in an extreme case. In such cases there is little or no discoloration apparent in the first half millimeter of tissue from the cambium, although other features of Brown Bast are in evidence.

The distribution of tannin in the cells of normal cortex is not always apparent in the fresh material. It is only when the tissues are fixed, *i.e.*, when the protoplasmic contents have been killed and all the tannin is thrown down, that the distribution of tannin, etc., is evident. This is probably accounted for by the fact that in normal tissue the inner cortical cells contain an amount of tannin which is not excessive and which can be carried. As these cells are pushed further and further out the amount of tannin increases, and is finally deposited by the time the cells are passed further to the outside. When the tissue is fixed, however, all the tannin in every cell is deposited, and its distribution is easily seen. In Brown Bast cortex, on the other hand, the distribution of tannin is evident previous to fixation, owing to the increased amount, due to extra meristematic activity in the vicinity of cells which may already contain a certain amount of tannin, it may be almost a maximum amount, without deposition. In some cells the tannin is present in the form of minute separate grains, uniform in size: this rather suggests precipitation. Other cells contain tannin in the form of irregularly shaped branching threads, more or less cylindrical: this would appear to be the result of a steady accumulation rather than of complete precipitation at one time; while in the case of cells which are completely filled with tannin such would also seem to be the result of a steady accumulation of this substance, rather than a complete precipitation at one time.

IV.—Many of the cells of the cortex become meristematic, more especially those in the immediate vicinity of the latex vessels, the newly-formed tissue sometimes becoming lignified. The meristem tissue is found at varying depths in the cortex, depending on the incidence of the disease and the time and rate of progress inwards. In advanced cases it is present quite close to the cambium in a portion of cortex where the laticiferous vessels do not yet contain latex as latex. This meristem tissue arising at a point in the cortex quite unusual as compared with normal cortex, may be considered the distinguishing feature

of Brown Bast cortex, and is present very frequently deep-seated in portions where no discoloration is apparent, especially is this so when an early stage is found quite close to the cambium. Many results of a secondary nature follow from this (Plates 16, 17, and 18). The meristem in the vicinity of the latex vessel causes partial displacement of the latter, frequently followed by rupture. It may be that the coagulation of the latex is due in some cases to some of the by-products of metabolism from the active meristem in the immediate neighbourhood. The coagulation of the latex is also probably closely connected with the formation of new tissue from the meristem activity of cells in the immediate vicinity of latex vessels, owing to the withdrawal of a portion of the water from these vessels into the surrounding actively dividing tissue.

A further effect of the presence of a cylinder of meristem tissue surrounding one or more latex vessels is due to the fact that the passage of fluids from portions of the cortex beyond the meristem area to the latex vessels will be wholly or partially stopped over certain areas, *i.e.*, such fluids will not pass the limits of the meristem tissue towards the latex vessels, or, if they do so, only at a much decreased rate.

The net result of the meristem activity then, is the coagulation of latex in the latex vessels, displacement of parts of latex vessels, or owing to the new pressures set up by the abnormal development of new tissue deep in the cortex, the latex vessels are ruptured, and latex percolates into the intercellular spaces and there coagulates. The presence of the serum from the latex vessels in the intercellular spaces is likely to cause further changes in the surrounding cells.

The physiological functions of tissue immediately adjacent to the meristem areas will of necessity be affected to an extent depending on the effect—displacement, etc.—of the latex vessels. The coagulation of latex first strictly localised may in some cases spread along the latex vessels to portions of cortex below where meristem activity is not yet present, *i.e.*, it may under these conditions precede the formation of new meristem tissue, but will at a later stage give rise to further new tissue formation from meristem activity.

Once coagulation of latex occurs in vessels which are comparatively young, and which lie more or less deep-seated in the cortex, *i.e.*, at a depth in the cortex where in normal tissue the latex still remains fluid, or where in vessels of the same age in normal cortex the latex still remains fluid, movement

of the contents of the latex vessels ceases at this point; a further source of irritation is present, sufficient to stimulate the surrounding cells into activity, and such areas are partially isolated by new growth round them. This new growth which takes place may continue as a (simple) meristem tissue, or it may become a new secondary cambium cutting off cells inside, which becomes woody tissue and later lignified, and outside, but to an almost inappreciable extent, new cortical tissue.

Brown Bast burrs originate in this way. It would appear that occasionally this new cambium produces cortical tissue at an almost normal rate, in which case the burr is quickly cast off.

It follows from such meristematic activity that by-products of metabolism will be passed into surrounding tissue already highly charged with these substances, the result being a deposition of the excess; the large amount of tannins in Brown Bast cortex may be due largely to this. Possibly the calcium oxalate present is to some extent a measure of the increased acidity as found by Belgrave in some Brown Bast cortex.

The sieve tubes in normal cortex are present as functioning tissue to a point 1·2 to 1·8 mm. outwards from their point of origin, hence the presence of meristematic tissue at a point deeper in the cortex than 1·8 mm. from the cambium is of considerable importance, especially when it occurs to such an extent as to cause considerable displacement of sieve tubes as well as latex vessels. In such cases the effect on the sieve tubes is very similar to that on the latex vessels.

When new tissue formation due to meristem activity takes place in the first millimeter of cortex from the cambium, no matter whether the meristematic activity has originated near there, or is the result of a gradual increase in depth of the disease from a point much further out in the cortex, brown discoloration due to tannin may not be present, or if so only to a very small extent. There are, however, cases where the disease at this point has reached an advanced stage, which show a pronounced discoloration through the cambium to the wood elements beneath, but this discoloration is never present to the same extent that one finds further out in the cortex. (When no discoloration is evident in this deep zone, though the disease is present it is scarcely probable that such tissue would be removed by any system of scraping.)

We do not think that in any case the meristem activity originates quite near the cambium layer, but is in all cases

the result of meristem activity arising in the first case further out, the point depending on the depth of tapping. Examination of a large number of cases supports this view, as similar diseased tissue is always present in an adjoining area at a point further out in the cortex.

V.—The cells on the outer limits of the meristematic area described under IV. are largely converted into stone cells, due to the fact that in them is deposited some of the by-products of metabolism from the adjacent actively dividing cells. Frequently other series of stone cells or sclereides are present nearer the original meristematic tissue, leaving an active meristem between more or less continuous layers of scleritic cells. When meristematic tissue lies between almost continuous layers of sclereides (which is sometimes the case) these latter, owing to pressure set up by the production of new tissue, are in time forced apart in sections, the new growth appearing then between the scleritic masses, which have been isolated. Tannin masses and large single crystals or spherical masses (calcium oxalate) are of frequent occurrence in these sclereides. Sometimes every scleritic cell over a limited area contains one or more crystals of calcium oxalate. Similarly the presence of tannin is constant in other series of sclereides, and occasionally both substances are present in the same sclereide.

The formation of stone cells (sclereides) frequently occurs in Brown Bast cortex to an extraordinary degree (Plate 9). Sometimes almost the whole of the affected zone is bounded both on its inner and outer edges by practically continuous lines of scleritic masses, which may both longitudinally and laterally over the whole affected area form a more or less complete enveloping network. At a later stage cleavage often occurs along the line of this stone cell area, or rather between the two areas, and the outer portion is easily detached as a scale, leaving the dirty white or pale cream coloured irregular net-work of sclereides exposed. Very occasionally the network is completely closed, and the sclereides form a continuous sheath. In such cases when the scaling occurs the disease has in every case which has come under our notice already passed inwards to one or more zones, and later the process of scaling is repeated. We have rarely seen burr formation taking place in these cases. Sometimes the effect of new tissue formation, even at a considerable distance from the cambium, as evident much deeper in the cortex, causing the formation of large masses of sclereides considerably deeper in the cortex than is

found in normal cortex. This occasionally occurs to a remarkable degree, disappearing again immediately outside the affected portions. It is probably closely connected with deep scaling, and at times may be responsible for the formation of minute pads of coagulated latex, as found sometimes deep in the cortex. Such pads rarely exceed one millimeter in diameter, and are usually smaller.

Any living cell of the cortex may become a sclereide under certain conditions.

Usually this is determined by the presence of excreted substances, such as tannins and calcium oxalate, hence the presence of an excess of these excreted substances results naturally in the formation of sclereides to an unusual degree, and in portions of the tissue where under normal conditions they do not occur, or occur only sparingly. The increased amount of excreted substances in Brown Bast cortex is due primarily to new tissue formation. We may consider the sclereides present in Brown Bast cortex as originating in either of two ways :—

(*a*) Normal cells of the cortex, *i.e.*, cells directly derived from the original cambium may become stone cells.

(*b*) Cells arising from the secondary meristematic tissue may become stone cells. These are characteristic in Brown Bast tissue, and are in addition to those under (*a*). They are never present in normal cortical tissue. Frequently the origin of the sclereides is evident, as shown in traverse section (Plate 9), the sclereide being the last (outermost cell) of a line of cells, the innermost one being the original meristematic cell. Sometimes such sclereides appear in small groups, forming a more or less complete ring round the meristem area. By further development of meristem these may be forced apart, *i.e.*, the groups may become more or less widely separated, finally appearing as a rosette, the individual groups being separated by bands of new tissue, which again may be terminated by a second series of stone cells. Occasionally the whole of the new tissues arising from the meristematic activity of cortical cells becomes a mass of stone cells, containing much calcium oxalate and tannins.

V (a). *Zones.*—When the Brown Bast tissue occurs in more or less definite zones with normal cortical tissue between,

the positions of such zones are determined by the proximity of the latex vessels. Usually the outer zone shows the presence of a larger number of scleritic cells, a greater development of new tissue from the meristem, and a more pronounced displacement of the latex vessels displaced, than the zone or zones nearer the cambium (Plate 8). This may be taken as evidence in support of the view that Brown Bast spreads inwards. The fact that in advanced cases, or in less advanced cases where the origin has been deep-seated, Brown Bast extends down to the cambium layer is further evidence of this. There are cases, however, where a greater development of meristem tissue occurs at scattered points near the inner face of the cortex, later spreading downwards and upwards in somewhat irregular lines, and, owing to the pressure exerted on the cambium, retards development of normal cortical tissue (Plate 14). In this way crevices are caused in the woody tissue, into which the new meristem tissue fits in the form of pegs or ridges.

This tissue, as seen when stripping the cortex, is frequently mistaken for burrs, but as shown by examination in section, the tissue is not lignified, and wood elements are not present. It does not necessarily follow that meristem activity originated here, in fact such is probably not the case, as other portions of the cortex either above or below this point usually show a very pronounced development of meristem, and considerable displacement of latex vessels in a zone further from the cambium (see Distribution of Brown Bast tissue). In some cases sclereides are formed when the meristem tissue has attained a thickness of not more than four cells, but this early formation of sclereides only appears in the outer zones as a rule. This early formation of sclereides may be due to the fact that the new tissue is surrounded by tissue very much older, and therefore contains a considerable amount of by-products (tannin, etc.), so that they cannot act as storage cells for the by-products of new meristem tissue, hence older portions of the new tissue act as storage cells of the by-products of metabolism. In some cases when the origin of Brown Bast is deep-seated a layer of tissue outside the first affected develops Brown Bast, *i.e.*, the disease can spread either inwards or outwards. In other cases examined where several zones of diseased tissue were present, the most advanced stage was the middle zone, suggesting that the disease had spread both inwards and outwards. Sometimes the disease is restricted to a single zone of tissue, *i.e.*, to tissue containing one ring or group of latex

vessels. This may be an early stage, and if it persists as such, the diseased tissue will possibly be eventually cast off. This, however, cannot be relied upon, as one cannot say in any particular case that the disease will not pass to deeper portions of the cortex.

VI.—The latex in the vessels central to the meristem is usually coagulated. It is often noticeable that some change has taken place in this coagulated latex for the reaction with Sudan III. is not always the same.

VII.—Latex vessels are in some cases ruptured, by the pressure of stone cells produced from meristematic tissue at a point further out, or deeper in the cortex. In this case, too, the coagulated latex, which is diffused among the tissue, would prove a secondary cause of irritability, setting up further meristematic activity. This is a secondary effect.

VIII.—The meristem which is formed, sometimes acts as a secondary cambium, cutting off cells which become woody tissue inside, *i.e.*, on the side nearest the latex vessels, and to a very much smaller extent, cells which become normal cortical tissue on the outside; this new cortical tissue may be exactly similar to normal cortex. The proportion of woody tissue formed is usually out of all proportion to the cortical tissue. One or more latex vessels or portions are always present in or along the centre of the burr (Plate 13). The latex in these is always coagulated, and frequently has undergone some change in composition. The structure of the burr (woody tissue) is very similar to that of the normal wood, consisting of pitted tracheides and vessels, the latter not being very numerous. There is frequently much distortion and irregularity apparent comparable to what is usually present in most burr formation. Starch is never abundant in the tissue of Brown Bast burrs, and the grains are usually very small. Many of the cells in close proximity to and surrounding the latex vessels, in the centre of the burr, are densely filled with a brown substance resembling tannin. This only occurs sparingly in widely scattered cells further out, and towards the periphery of the burr; it is frequently altogether absent (Plate 14). Sometimes such burrs cause the underlying surface of the normal wood to be very uneven, due in part at least to the pressure which retards normal development from the cambium, and finally the burr may fuse with the normal wood at one or more points, so that the whole appears a homogeneous structure. Fusion between the burr and the normal woody tissue invariably occurs

only at points, usually scattered. It seldom takes place over the whole inner surface of the burr. We have noticed that the connection between the burr and the normal wood frequently forms along the line of a medullary ray, the connecting portion being in the form of a narrow cone with the point towards the cambium (Plate 14). Apparently this new secondary cambium does not always give rise to both wood and cortex elements. Sometimes it would appear as though it gave rise to wood elements only, as cortical tissue is not formed. Sclereides are not usually present to a large extent in the immediate vicinity of burrs, or where burr formation is taking place. Sometimes a considerable amount of calcium oxalate is present in the vessels of the burrs, but this is not a constant feature.

Burrs formed in this way may, if not deep-seated, be gradually passed outwards and thrown off, but there is always the possibility of their becoming attached to the wood. More serious still, there is always the danger that the burr-formation may follow the line of one, or a group of latex vessels, and extend quite a long way up or down the stem, finally forming one elongated, large, compact, uneven, nodular mass, making the cortex almost or quite untappable. Whenever, owing to Brown Bast, latex coagulates in portions of latex vessels, the liability to burr formation follows, but this does not always take place, since the new meristematic tissue does not always act as a secondary cambium.

Since Brown Bast burrs do not apparently originate beyond a certain point in the cortex it would appear that the age of the cortical cell giving origin to burr formation is possibly a governing factor. The constitution of the cell contents, which again depends to some extent on the position of the cell in the cortex, and therefore is largely governed by the age of the cell, is possibly another factor which limits burr formation to certain portions of the cortical tissue. It does not even follow that deep-seated Brown Bast will invariably, or even in the majority of cases, give rise to burr formation; but a deep-seated form of Brown Bast may, owing to the presence of meristem tissue irregularly distributed over the inner surface of the cortex, give rise to a very uneven surface on the underlying wood. More or less deep clefts, sometimes of considerable length, are often seen, due to the local retardation of cambium activity, the result of pressure from the new tissue formation due to meristem activity. At the same time we cannot say that burr formation

is in any way limited to trees in particular areas under cultivation.

From the preceding we consider that IV. is the constant characteristic feature of Brown Bast cortex.

Viz., the presence of meristematic tissue, almost invariably in the vicinity of latex vessels, the latex in the vessels enclosed in the meristem tissue being usually coagulated. The remaining characteristics of Brown Bast cortex, *e.g.*, the deposition of tannins, calcium oxalate, excessive quantity of sclereides at an unusual depth, often very deep-seated, depletion of starch, etc., we consider to be secondary symptoms arising directly as a result of meristem activity.

The disease is diagnosed by the secondary symptoms, which give the characteristic appearance of Brown Bast cortex, viz., the typical brown, or olive brown discoloration, the watery appearance of the cortex in more advanced cases, and the lack of latex flow from a part of or the whole cut. The real cause of this appearance in the outer cortex is frequently more deeply seated, and may in some cases have penetrated to points quite close to the cambium.

In formulating a theory as to the cause of Brown Bast, the following factors have been taken into consideration in addition to what we have noticed in the microscopical examination of the tissues :—

I. The disease is limited to trees in tapping. (Wounding is here considered as equivalent to tapping.) We have never seen a case of Brown Bast in an untapped tree. Supposed cases have come under our notice from time to time, which have proved on investigation not to be affected with Brown Bast.

II. Brown Bast is distributed over the whole rubber producing areas of the East where trees are in tapping. It is probable that Brown Bast is present on every estate on which trees have been in tapping for six months or more.

III. The depth of incidence corresponds in general to the depth of tapping.

IV. The disease almost invariably occurs below the tapping cut, or on a sector to the right or left, in which case its origin in the second sector can usually be traced to the cut in the first.

In a large number of cases the beginning of meristem activity can be definitely traced to a point or points immediately below the cut (Plate 17A). The points of origin are very small in extent, and as a rule only affect one or two latex cylinders at first. Passing downwards following the line of these vessels the meristem area becomes more pronounced, in the form of an ever-widening flattened cone, the apex being uppermost. At a point in the cortex where latex vessels begin to degenerate, or even before that point is reached, that side of the cone may become parallel with the latex vessels and remain constant; but on the inside the angle of spread is frequently extended, until a point is reached where the latex vessels do not yet contain latex as latex.

Beyond this point, towards the cambium, there is rarely any discoloration. In some cases one or more zones of latex cylinders to the outside of those originally affected never become affected, because the "disease" takes a parallel course to the latex vessels on the outside margin. When this occurs latex vessels near the outer edge of the cortex continue to yield freely, succeeding rings of vessels passing inwards remain dry, and these may be succeeded by others still deeper in the cortex which yield latex. The latter depends on the point at which the cortex is tapped, and on the time the disease has been present.

V. The constant and most important characteristic feature of Brown Bast cortex is the presence of an active meristematic tissue, generally originating at a point approximately equal to the depth of tapping, or from one or more points along the under side of a finished cut.

VI. Well grown, or well developed trees are more liable to the disease than slow-growing, poorly-developed, thin-barked trees.

VII. The percentage of cases increases with the age of the trees so long as tapping continues, but may not be of necessity directly proportionate.

VIII. In many cases the percentage of cases of Brown Bast bears some relation to the interval between successive tappings (see p. 22).

i.e., The more frequent the tapping and the greater is the liability to develop Brown Bast. This may not be directly proportionate to tapping periods, however.

IX. Repeated experiments have failed to connect the percentage of Brown Bast cases with the yield of latex, *i.e.*, the percentage of cases of Brown Bast bears no relation to yield in any particular areas.

Incidence of Brown Bast on areas under daily and alternate daily tapping.

The figures quoted below are from experimental plots, the complete history of which is known. The trees are now 13 years old. The land is fairly level, low-lying, and well drained, and the areas are adjacent blocks of 4·33 acres each. The original planting was throughout 161 trees per acre, and an average of four trees per acre have been taken out because of root disease. No cases of Brown Bast have been removed, so that for practical purposes, as far as Brown Bast is concerned, we may consider that all the originally planted trees still remain.

Tamil labour has been employed throughout, and each tree has been tapped by each tapper in succession, hence the personal factor has been as far as possible eliminated. The tapping throughout has been exceptionally good, and the trees have been carefully treated. No manures have been applied at any time to these areas. The growth of the trees is not especially good in either area, and the soil not above average in fertility.

The figures may be accepted as reliable, but emphasis must be laid on the fact that the areas are small.

DAILY TAPPING.

2 Cuts on one quarter.

4·33 Acres, 680 Trees.

Year.	Cuts per inch.	Yield per tree per annum.	Yield per acre per annum.	No. of trees Brown Bast.	Percentage Brown Bast.
1915	24	4·28 lbs.	691 lbs.		
1916	22	4·98 ,,	804 ,,		
1917	21	5·85 ,,	946 ,,	52	7·6
1918	20	5·09 ,,	797 ,,		
1919	20	5·84 ,,	916 ,,		
5 years	107	26·04 ,,	4,154 ,,		
Averages	21·4	5·21 lbs.	831 lbs.		

ALTERNATE DAILY TAPPING.

2 Cuts on one quarter.

4·33 Acres, 680 Trees.

Year	Cuts per inch.	Yield per tree per annum.	Yield per acre per annum.	No. of trees Brown Bast	Percentage Brown Bast.
1915	22	2·53 lbs.	409 lbs.		
1916	20	2·60 ,,	421 ,,		
1917	18	3·64 ,,	588 ,,	22	3·2
1918	18	3·77 ,,	592 ,,		
1919	18	4·02 ,,	632 ,,		
5 years	96	16·56 ,,	2,642 ,,		
Averages	19·2	3·31 lbs.	528 lbs.		

No records of yields in either area were kept during the first three years of tapping.

The areas dealt with are unfortunately small, but it is almost impossible to obtain reliable data from any large areas of mature rubber, as so little accurate information can be obtained regarding trees removed and methods of tapping in the past. Taking into account the points enumerated previously (page 20) and detailed examination of a large amount of Brown Bast tissue, we consider the disease is due primarily to the operation of tapping.

It may originate in either of two ways :—

I. The disease may be due directly to the stimulus arising from the presence of a wound meristem below the cut, especially a finished cut, *i.e.*, the meristem tissue formed just below the cut surface and sometimes called a wound-meristem, continues a short distance below into untapped cortex, setting up secondary effects due to the coagulation of the latex in the latex vessels, which is the result of the original meristem activity. Once these secondary effects are present the disease may spread more or less rapidly, both laterally and in depth ; *or*,

II. The origin of the disease may be due to the stimulus arising from the formation of a cork cambium (meristem) in the tapped cortex, the stimulus finally passing down into untapped cortex below, where con-

ditions are very different from those obtaining in the tapped cortex above. In this case also the new tissue formation causes the latex to coagulate.

Whether the disease originates as I. or II., the *spread* both in area and in depth is due to secondary effects, *i.e.*, to coagulation of latex in the latex vessels, rupture of latex vessels, displacement of latex vessels, new tissue formation, and general interference with the functions of the cortical tissues resulting.

Lock (Rubber and Rubber Planting, 1913) was the first investigator to note that the stimulus which aids renewal passed into untapped bark. He wrote as follows :—" There is evidence to show that the effect of this stimulus is not confined to the area actually tapped, but that the bark of neighbouring untapped areas is also stimulated to more rapid growth."

Effect of Tapping.

In the operation of tapping a portion of the cortex is removed, and this is continued at frequent and regular intervals. A portion of cortical tissue 1—2 mm. thick remains on the tree. The remaining tissue as a direct result of tapping is stimulated into activity at an abnormal rate, resulting in the process known as renewal. This varies much in trees in different areas grown under different climatic and soil conditions, and is also affected by the severity of the tapping. In this remaining tissue (the tapped surface), at a point not far removed from the outer surface, a new cork cambium is quickly formed, but at a point or depth in the cortical tissue where normally a cork cambium is not formed, that is, the cells which become meristematic on the tapped surface do so at a younger stage in their life history than occurs under normal conditions. There is a negligible thickness of tissue which quickly dries and dies overlying this new cork cambium. It is highly probable that such abnormal growth provides the necessary stimulus to start meristematic activity at an equal, or almost equal, depth in the cortex below the tapping cut, *i.e.*, on the untapped portion of the cortex below, or in other words, the stimulus from new tissue formation in the tapped surface gradually passes down into the untapped portions of the cortex below.

The conditions in untapped cortex are very different from those on the tapped portion. There is a considerable amount

of tissue (living) superimposed, exerting a not negligible pressure, and, what may be termed "secondary growth," within this tissue will under those conditions increase that pressure locally, and at the same time draw on the cells in the immediate vicinity for the necessary water, with its contained mineral matter (cell sap), organic food material, etc., for the production of new tissue.

The partial depletion of starch in Brown Bast may thus be accounted for, and so long as new tissue production continues the presence of organic food material (sugars, etc.) may be expected. By-products of metabolism will be produced in an abnormal amount, for the age of the cells, and in the vicinity of cells which already contain a certain amount, hence deposition of at least some excess is only to be expected. This will vary naturally according to the time of progress, position in the cortex, and extent of the disease.

The coagulated latex, excess of tannins and calcium oxalate, as well as the isolation and displacement of portions of latex vessels and the development of scleritic cells, we consider to be secondary effects of the meristematic activity arising in the first instance.

It is probable once an area is affected, that the by-products of metabolism, new tissue formation, pressure, coagulation of latex, etc., may set up further derangements of the normal functions of the cells immediately outside the affected area, stimulating second, and even third, zones of tissue to similar activity, and give rise to an appearance, often met with, of Brown Bast occurring in zones from outside inwards, or vice versâ.

That the disease usually tends to pass into deeper portions of the cortex is evident from examination of tissue where two or more zones of affected cortex are present (Plates 7 and 11). In such cases the outer zone frequently shows a greater and more extensive development of meristem than the inner zones. A greater proportion of sclereides, crystals of calcium oxalate, and a more pronounced change in the latex vessels are usually apparent. The amount of displacement of latex vessels or of portions of them is, however, sometimes greater in the deeper zones; this is especially the case when the two zones are in close proximity, and is due to the effect of greater development of meristem on the inside of the outer zone. This is frequently the cause of the second zone of diseased tissues being formed. It is probable that tissue of a younger age, *i.e.*, further in the

cortex, under the peculiar conditions set up in Brown Bast cortex may tend to become meristematic more quickly than older tissue much further out in the cortex. It is also possible that once meristem activity commences in the younger tissue it may proceed much more vigorously than in older portions, so that deep-seated apparently older stages of the disease may really be of more recent origin than apparently younger stages in a zone further out in the cortex.

When the meristem acts as a secondary cambium the formation of burrs is started, and it apparently depends on the depth at which these are formed and on the rate of growth, as compared with the normal rate of growth or of Bast production from the original cambium, whether these finally fuse with the wood or are cast off with the outer bark (Plate 14). If the new cambium activity which gives rise to burr formation also produces at an almost normal rate cortical tissue outside, the fusion of the burr with the normal wood is usually prevented, and the burr may be finally cast off.

The percentage of Brown Bast in any particular area as compared with another, where the trees are the same age and subjected to the same conditions as regards tapping, may be regarded as a measure of their response to stimuli, *i.e.*, to the stimulus resulting from the operation of tapping.

All cell activity results as a response to stimuli, and trees which have grown vigorously have done so because of the ready response of the cells to stimuli, under the particular conditions determined by their surroundings. The generally larger percentage of Brown Bast affected trees in areas where Hevea flourishes (other conditions being equal) is a direct result of this. On the other hand, there are areas where Hevea does not thrive nearly so well, the trees are thin barked, because a younger stage has persisted in the cortical tissue, due to the fact that the response to stimuli under the particular conditions existing has been slow. In such areas the percentage of Brown Bast is small, as compared with the areas where the trees of the same age and under the same conditions as regards tapping, etc., are of more vigorous growth and are better developed.

It is probable that in cases where development is slow, so slow in fact that, so long as tapping is continued, the secondary effects are never apparent, because much of the affected cortex is removed during tapping operations before the secondary symptoms become pronounced, the trees show the development

of Brown Bast only when the cut is finished, *i.e.*, when the "disease" is given time to develop, at a depth in the cortex where so long as tapping continues the bulk of the diseased tissue is removed. This does not mean that the continuance of tapping can in any case be relied on as a means of removing affected tissue. In these cases Brown Bast may be found on the finished section some considerable time after a new section has been opened. The most likely place for it to appear is just below the finished cut. This is frequently observed in quite a large number of cases occurring in trees which have developed somewhat slowly. In other cases, however, where development is rapid the Brown Bast condition may be discovered during tapping operations on the first section opened. It may appear quite early, *i.e.*, two to five months after the cut is opened, or even sooner; especially is this to be expected when the spread of the disease, either inwards or outwards, is very rapid and the tree quickly becomes dry on the tapped section.

Under certain conditions meristematic activity may continue for some time on the untapped cortex without causing the latex to coagulate locally. When that occurs the amount of growth will be strictly limited and may soon cease, since the secondary causes of further meristem activity are not present, and may never occur to any great extent.

On the other hand, there will arise some occasions when the latex is more easily and quickly coagulated, or in other words, when the stability of the latex as latex is more easily upset, as during or immediately after a more or less prolonged dry period, when there is some difficulty experienced by the tree in supplying the necessary requirements as regards water, to sustain the activity which is constantly continuing on the part of the cambium, and at the same time maintain the necessary percentage water content of the latex. Any extra meristematic activity under those conditions, since such means a further charge on the water supply, most probably from the latex vessels in the vicinity, would possibly cause local coagulation of latex, thus setting up the secondary conditions of irritation which once started may continue in increasing intensity. Tapping during and immediately after the wintering period may therefore be considered, in some cases at least, as a contributary cause of the increase in the production of Brown Bast. Such has been noted, for it has frequently been noticed that many fresh cases of Brown Bast appear shortly after the

wintering period. These are not necessarily all new cases, *i.e.*, the disease may not have started just previous to notice, but rather the extra drain on the water supply during the drier period is just the condition, continued with the abnormal meristem action, which cause the secondary symptoms to appear quickly. The disease may have originated before the wintering season. The increase of the number of cases during a wet period immediately following a period of drought or the wintering season is sometimes marked, and has been, wrongly we think, attributed to the influence of heavy rain.

If the original incidence of attack is not deep-seated, the normal Bast formation may be such as to succeed in casting off nearly all the affected tissue with the outer bark, before the effect in the deeper layers of cortex has been sufficient to give rise to new meristematic activity. This cannot, however, be relied upon. It is impossible to say in any particular case that the disease will not spread to deeper portions of the cortex. There always remains the possibility, in fact probability, that it may do so. Exactly the same position holds with respect to the spread outwards. It is because of the former that we cannot recommend resting Brown Bast trees as a possible cure. It is highly probable that in the great majority of cases such a procedure means the extension of the diseased area, and also an increase in depth, followed in some cases at least by burr formation.

We have on many occasions seen trees affected with Brown Bast which have been rested for periods of a half to three years. In no case had the trees recovered, but the diseased area had increased, sometimes to a considerable extent. In other cases the disease had passed inwards, and some showed burr formation. The increase in area is, however, in some cases extremely slow while the trees are rested.

Deep longitudinal channels act for a time as a bar to the spread of Brown Bast laterally, but once regenerated cortex has bridged the channel, *i.e.*, has attained a thickness equal to the most deeply seated zone of affected tissue, the disease then spreads laterally across the "bridge."

The occurrence of Brown Bast in more or less well-defined triangular areas, the base or apex being on or near the finished cut, has been frequently observed.

Distribution of Brown Bast Cortex in Affected Trees.

The extent of the affection can only be determined by a careful examination of the cortical tissues. If the case is an old-standing one, the affection may have spread all round the tree, some distance below ground on the tap root, and even along one or more laterals. The depth of the affected tissue and the degree of the affection may vary in different places.

Sometimes it appears as though the diseased cortex was present in isolated patches more or less distant from each other (Plate 20B). This appearance must not be relied on, for it usually means that the whole area is diseased, but that the diseased portions are situated at different depths in the cortex (page 16). This is due to the fact that new tissue formation is uneven in depth or thickness, and secondary effects will naturally follow the same lines. The only safe plan is to consider the whole area, which includes apparently more or less isolated affected patches as a completely affected area, otherwise it will almost certainly follow that affected portions of cortex are left after treatment, and the disease is bound to continue.

Once a portion of the cortex develops Brown Bast, say in one zone only, or along a single cylinder of latex vessels, the disease may spread inwards or outside or laterally owing to secondary effects (Plate 7B). The extent to which this may occur will depend on the position, *i.e.*, depth of the original attack, on the progress made, and on each individual tree. The original attack may develop so quickly in one zone, *i.e.*, the secondary meristem activity may be so rapid that other zones either further in or further out in the cortex may be affected very quickly, and in the same way lateral spread may be equally rapid. It is chiefly because of this that the policy of resting affected trees does not, nor is it likely to give good results, even if burring does not occur. In the great majority of cases not only will the disease persist, but the affected area is almost certain to increase in extent more or less quickly. Besides extending laterally the disease will in the majority of cases also increase in depth, and even if burring does not follow, the tree or the affected portion remains useless so far as latex yield is concerned.

Some extreme cases of rapid spreading have from time to time been noticed.

On one estate the young rubber (seven years old) contained

several trees which were affected all round. The "disease" had apparently commenced just below the first finished cut passed round to the second sector opened and simultaneously into the last section consisting of virgin bark. The increase in depth had also been rapid, and in parts the wood was much discoloured (tapping was on 1/3). It was very noticeable that the great majority of the trees affected were of more than average size. One tree, thirty-four inches at three feet level, was affected all round and to the cambium on the first section opened.

Distribution of Brown Bast.

The figs. I. and II., Diagram I., represent diagrammatically the distribution of Brown Bast in a portion of affected cortex stripped from a tree thirteen years old. The cortex was first scraped somewhat heavily, leaving a portion about 3 mm. in thickness and exposing the diseased discoloured areas.

In No. I. the affected areas A and B were deep-seated, the innermost portions of the stripped cortex in those areas being much discoloured. Microscopical examination of portions of these areas showed the typical symptoms of Brown Bast.

The area D between A and B showed no discoloration on the inner surface, but a transverse section along the line (*a*) to (*b*) is represented in fig. III. where the dotted line indicates the presence of a zone of Brown Bast tissue (*c*) lying further out in the cortex. At two points X and Y this zone was superimposed on the innermost zone of diseased tissue. The area C in fig. II. shows the distribution of Brown Bast in this zone. The area C showed throughout a more advanced stage of the disease, which suggests that the disease had arisen in that zone and passed to a deeper point in the cortex at some point or points along the lines X and Y.

A second strip of cortex four inches deep was removed immediately below the previous one and along the base, and about one inch above there was no Brown Bast (area X Y, fig. IV).

Fig. IV. shows the distribution in this second strip.

DIAGRAM I.

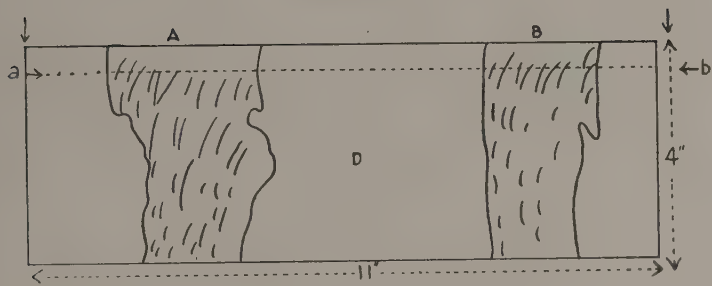


FIG. 1.

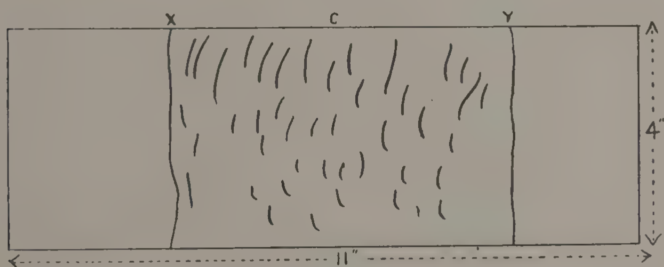


FIG. II.

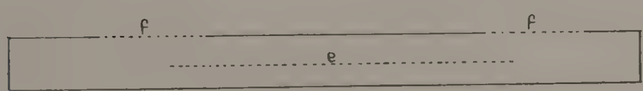


FIG. III.

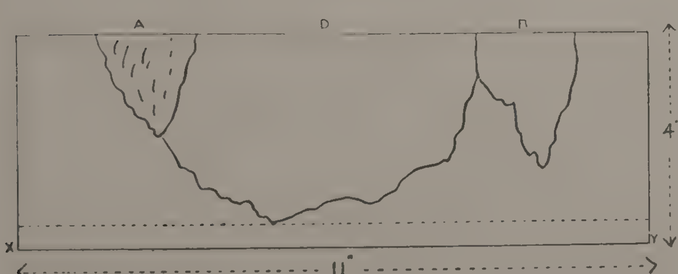
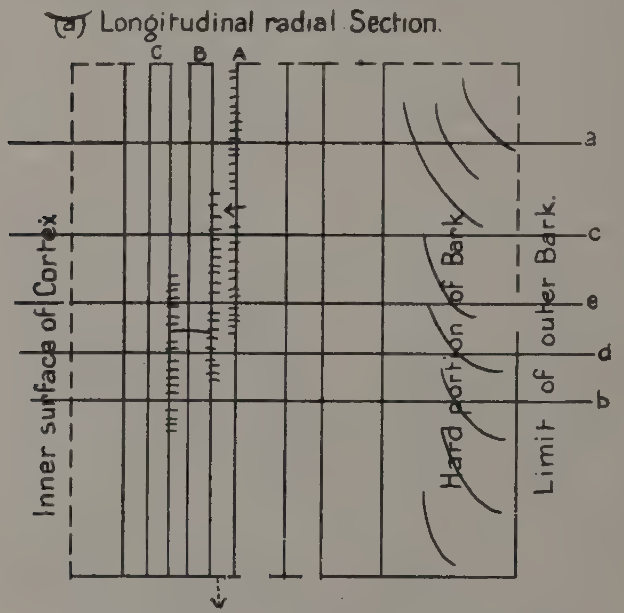


FIG. IV.

DIAGRAM II.

(*a*) Longitudinal radial section of Brown Bast cortex

(*b*) Tangential section of Brown Bast cortex.



(b) Tangential Section between A and B above.

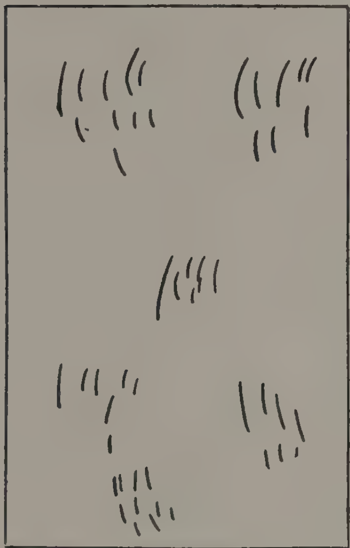
(*a*) The vertical lines indicate the positions of cylinders of laticiferous tissue.

A is the zone originally affected by Brown Bast.

The short black connecting line shows where the disease passed inwards to B line, a further connection communicating with C line deeper still.

A transverse section at (*a*) or (*b*) would show only one zone diseased.
" " " " (*c*) " (*d*) " " " two zones "
" " " " (*e*) " " " three zones "

b



A true tangential thin section would include only a single zone, but unless through its centre this might be represented by a series of apparently disconnected patches varying in size (Diagram II., fig. (*b*)), since the development of meristem tissue does not necessarily proceed evenly over the whole affected area : in fact, there is very great variation, depending partly on the time the disease has been progressing along the cylinder or groups of latex vessels.

Brown Bast areas shaded. Such areas contain meristematic tissue, or new tissue derived from a secondary meristem in the cortex.

Fig. I. Diagram III. represents diagrammatically the plan of an area affected by Brown Bast.

In fig. II. a longitudinal radial section of the area along the line *a*—*b* is represented by *a′* or *b′* or *c′*

The point A is the point of origin of the Brown Bast.

a′. It will be observed that the affected area gradually increases in thickness downwards. Latex would be obtained from any part of the cortex shown as dots, but passing downwards this would be in a steadily decreasing amount from *ab*—*cd*. At the latter point

the cortex would be completely dry, since the whole area of cortex which should produce latex is affected with Brown Bast.

The angle at A is a very variable one, depending on the rate of development in each individual tree.

b'. As in a', a gradual increase in thickness of affected tissue is shown, and from the inside of the Brown Bast the latex yield ceases at the same point as in a'.

Sometimes the disease on the outer margin follows a line parallel to the latext cylinders (e), and in consequence the region of cortex outside this line continues to yield latex, until by further growth in thickness the portion e reaches a point in the cortex e', where the latex vessels naturally degenerate. By that time the whole thickness of cortex is affected, and complete dryness results.

c'. There are cases where the position as b' is reversed, *i.e.*, the outer portion at a point ceases to yield, but owing to a parallel course inside, a small amount of latex can be withdrawn down to e'.

This zone in turn is affected and ceases to yield by the time it reaches e, but meanwhile further new laticiferous tissue produced from the cambium has reached the point e', and yields latex as before. This is a case where the spread inwards is exactly counterbalanced by the growth in thickness of the cortical tissue.

DIAGRAM III.

Distribution of Brown Bast downwards from the cut (Diagrammatic).

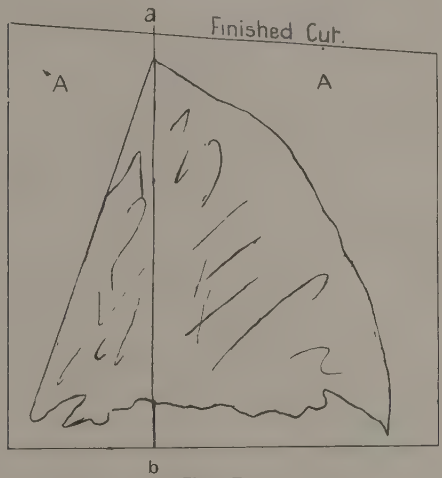


FIG. I.

The point A is any point just below the cut and in the vicinity of a latex vessel. The outer bark has been removed to expose the outermost zone of Brown Bast tissue.

Assuming for the present purpose in order to simplify matters that Brown Bast originated in this case at one point only, at first affecting a single latex vessel or a small portion of one cylinder of latex vessel. Fig. II. represents what sometimes occurs as seen in longitudinal section along the line a—b (Fig. I.).

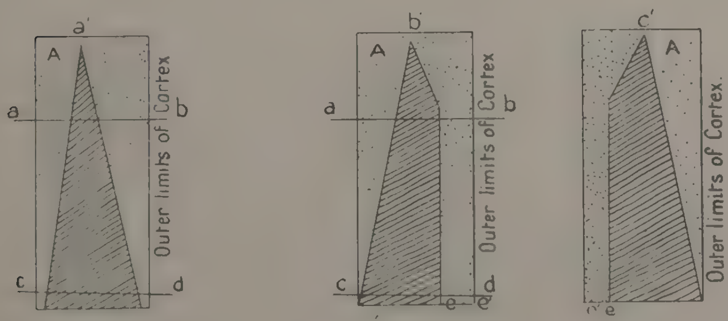


FIG. II.

Incidence of Burr Formation.

The following figures with regard to burr formation are from an estate on flat land with stiff clay sub-soil, but where the growth is very good; in general, the trees are better than average.

The tapping is alternate daily, and over the whole area the number of cuts per inch bark consumption averages about thirty. The census was completed at the end of October, 1919.

The extreme variation in percentage of burred trees is most noticeable.

Field. Acres.	Age of trees. Years.	Total Brown Bast.	Brown Bast Burred.	Percentage of Brown Bast Burred.	Burred trees per acre.
90	14	716	43	6·0	·47
127	13	818	475	58·0	3·7
33	14	225	117	52·0	9·0
30	14	124	18	14·5	·6
220	12	1,633	662	40·5	3·0
107½ A	10	447	88	19·6	·82
100	10	618	79	12·7	·79
200	9	224	25	11·1	·12
107½ B	10	70	48	68·5	·42
	Totals	4,875	1,555		

Percentage of Brown Bast trees burred throughout the whole area ... ... 31·9,

or approximately one Brown Bast tree in every three affected becomes burred.

Brown Bast and Number of Cuts per Inch.

The figures quoted below are of considerable interest.

Block.	Field. Acres.	Age of trees.	Tapping cuts per inch.	No. of trees with Brown Bast.	Brown Bast trees per acre.
1	100	10	40	1,312	13·12
2	100	10	30	455	4·55
3	200	9	30	441	2·20
4	100	10	30	325	3·25

Except for the slight difference in age in the four blocks, the only variable factor is the number of cuts per inch. Too much should not, however, be read into these figures, for the

figures over the different fields all over the estate for Brown Bast vary to an extraordinary degree. The percentage of burred trees on the same estate is also a very variable figure.

Treatment.

From the foregoing description, observations as regard the increase in extent of diseased tissue, burr formation, inefficiency of resting, etc., certain lines of treatment are indicated.

We are forced to the conclusion that any system of tapping as at present practised may give rise to Brown Bast, the percentage of cases depending partly on the individual susceptibility of the trees. General observation bears this out, as trees under all the different systems of tapping are attacked. Only exhaustive experiments in tapping methods would give any idea as to the best system for the limitation of the disease, and in any case, no matter what the system of tapping, it is very doubtful if, so long as the tree is subjected to the operation of tapping by the removal of small portions of cortex at frequent and regular intervals, the disease can be prevented in a certain percentage of cases. The percentage of cases over a limited period of time might, however, be reduced.

Alternate daily as opposed to daily tapping would probably give rise to fewer cases of Brown Bast over any particular period of time, but the number of cases would still tend to increase with the age of the trees. It follows then that, apart from an alteration in tapping systems and periods (and there is as yet no reliable data to work on), preventive methods cannot be outlined.

Treatment, however, can and should be taken in hand, more especially with the younger areas of rubber, for in the older rubber, over twelve years, it will be found both difficult owing to burring and costly, but treatment of the younger areas can be done cheaply and effectively and burring prevented, and it should be remembered that burring in the majority of cases renders the tree valueless as a revenue producer.

I. The necessity for the removal of affected tissue is evident, since the spread of the disease is due to secondary effects.

This is most effectively done by stripping the cortex of the affected area. An obvious objection may be raised to this line of treatment, viz., the same conditions are set up, but at a greater depth,

as those due to tapping operations. This is not so, for once a cork cambium is formed regeneration proceeds as in normal cortex. It is possible, however, that in a small percentage of cases further affections of Brown Bast may be set up in the cortex adjacent to the stripped surface. Probably such cases will be due to the fact that all the diseased cortex was not removed in the first instance.

II. Scraping off the affected tissue has been recommended and practised to a considerable extent. This is apparently a much simpler operation than stripping, but there is always a doubt whether all the affected tissue has been removed; if not, the disease will still continue. It is quite possible that this method may be effective in some cases where the disease is not deep-seated, and has not persisted for a very long period. Two forms of scraping, light and deep scraping, have been practised. The former method has nothing to recommend it, as it is extremely doubtful if even one per cent. of cases will be benefitted at all. The latter method presupposes either a deeper incidence of the diseased conditions, or spreading inwards of the disease from a point further out. By deep scraping, if it is to be successful in even a small percentage of cases, it is necessary to remove all the affected cortex, if necessary until only a very thin cover is left. There are many cases where diseased tissue may be left, and in those cases where the discoloration extends down to the wood removal by scraping is quite impossible. This method is always of doubtful utility in a considerable percentage of cases; there is considerable danger of wounding on an extensive scale, it is quite as expensive and delicate an operation as stripping. The only point in its favour is that the new cortex may be tappable a little earlier than in the case of stripped areas.

III. Treatment with tar, or various tar mixtures or other patent preparations, after scraping, is practised in some areas. Such treatment may be useful temporarily to keep out borers, etc., which may attack scraped cortex, but otherwise we cannot understand the application of tar, etc., having any effect on the

disease, unless the penetration is so great as to kill all the affected cortical tissue to a considerable depth. (We have seen very few cases of cortex scraped for Brown Bast attacked by borers.) If this fact is relied upon for treatment, there is, owing to the unreliability of different samples of patent preparations as to depth of effective penetration, etc., considerable danger of the cambium tissue being killed, especially after deep scraping; a large wound would thus be caused. Tar and tar mixtures, residual oils, crude oils, tar oils, etc., act as irritants to the cortical tissues; some of these contain toxic substances which are harmful to the tissues, and in addition highly penetrative substances may be present. We have seen many cases treated by this method, *i.e.*, some form of scraping followed by the application of tar or tar mixtures as a cover, which resulted in "bleeding," *i.e.*, rupture of latex vessels and exudation of latex on a considerable scale. In some cases pads of coagulated latex of considerable size were found; this is decidedly harmful. We therefore regard stripping, although apparently a very drastic method, as safer, less costly, and more effective than deep scraping, followed by the application of tar or tar mixtures, etc.

The objection has been repeatedly urged against stripping that the regenerated cortex will not be tappable for at least four, and possibly six, years. That may be quite true, but even six years is not an abnormal time to allow for renewal in the ordinary way. At the same time one may point out that regeneration of cortex over a stripped surface is extremely rapid, especially during the first six months.

A further objection has been mentioned against stripping, viz., that the thickness of cortex bears little or no relation to the quantity or quality of latex which it may yield. This is based chiefly on the supposition that the production of latex vessels is influenced by two factors :—

(*a*) Time.
(*b*) The individual tree.

Dealing first with the question of time and assuming that the average number of rings of latex vessels produced each year is two and a half, *i.e.*, in four years there would be ten rings of latex vessels, most of which, say seven, would be

opened by tapping. This would be comparable to an ordinary four-year-old tree as regards number, but the cut would be at least twice as long in, say, a ten-year-old tree, and longer still in older trees, which must be accepted as a compensating factor.

As regards the second point, there is no evidence to support the view that the regenerated cortex would on the average differ widely in constitution to normal cortex on the same tree. Besides, it is generally accepted that the yield per unit of cut increases as we pass inwards from the outer edge of the cortex; this can only mean that the younger latex vessels to a point yield more latex than older ones. This holds good even on trees first opened for tapping, say at five years old, and in this case, assuming that the deepest cut made taps the vessel of two years old, these are the richest reserve of latex for that particular cortex.

A point of some importance arises as regards deep scraping against stripping.

We will assume, for the sake of argument, that normally a period of seven years is allowed for renewal.

Deep Scraping.

After deep scraping a comparatively thin skin of inner cortical tissue is left, comparable to what remains after tapping. Given a seven years' renewal, the cortex would then contain towards the outer margin tissue, which at most would be, say, eight years of age.

Stripping.

The regenerated cortex over a stripped area would at the end of seven years consist of tissue the oldest part of which would be seven years old; but, if the diseased area had been properly delimited, this tissue would not contain Brown Bast, whereas in the deeply scraped cortex one could not guarantee that all the affected tissue had been removed.

With scraping of lesser depth the risk of leaving affected tissue increases.

It is very improbable, except in a few cases, that latex vessels over seven years old, even in old trees, are of very much account so far as yield is concerned, since when a latex vessel reaches a certain point in the cortex, which is determined chiefly by the age of that vessel, degeneration sets in and it no longer functions so far as yield is concerned. It is common know-

ledge that in tapping, much bark is removed which does not yield latex, and under normal conditions this amount increases to a point with the age of the tree. On the other hand, regenerated cortex at six years old will contain but a small number of latex vessels, which will have attained an age at which, owing to degeneration, latex cannot be drawn from them. One or two vessels, *i.e.*, those of most recent origin, may not yield, but this always applies in tapping, and the number of deep-seated vessels affected depends solely on depth of tapping. There is no reason to suppose that in the great majority of cases the regenerated cortex will not be equal to that of equal age on the same tree.

Allowing, say, six years for complete regeneration, there is no question as to the possibility of tapping over it again. In the great majority of cases a four years' regeneration will be ample.

One further argument may be brought forward here in favour of treatment, viz., it will enable tapping operations to be kept near the base of the tree. We have frequently seen trees affected with Brown Bast all round or heavily burred on one half, being tapped to a height of five feet, and below the three feet level such trees will never be tappable, which simply means that what should be the richest reserve of latex cannot be utilised. This is obviously false economy, and reaches its limit in those cases where trees become quite untappable, which should be yielding, say, four to six lbs. of dry rubber per year.

By stripping off all the affected cortex the spread of the disease to the remainder is prevented, burring is prevented, and the tree may be continued in tapping. If the disease has been discovered in good time so that the area of cortex to be stripped is small, there should be an ample amount of cortex left to continue tapping, so as to follow a four to five years' renewal, or even longer, for the regenerated area.

Concrete Examples where Treatment on a Large Scale has been Undertaken may be Quoted.

Estate A. Over ten thousand trees were treated by stripping. Regenerated cortex fifteen to twenty months old averaged five to six mm. in thickness. This should, and most likely will, be easily tappable by the end of the fourth year if necessary.

Estate B. Over twelve thousand trees treated. Regenerated cortex twenty-two months after treatment averaged six mm. in thickness. This also will probably be tappable in four years if necessary.

In the great majority of the above cases there is sufficient cortex remaining to allow of a five years' renewal.

In each of the above cases the regenerated cortex will certainly be tappable within five years.

Even if the yield from these treated areas is not quite up to normal when brought into tapping, before or in the fifth year, there is still the satisfaction of knowing that the remainder of the cortices has in the meantime been saved.

The alternative to treatment must be considered. Suppose stripping is not undertaken :—

(*a*) And instead the light or deep scraping method is resorted to. There are many chances of continuance of the disease in a great majority of cases. One cannot be sure that all the diseased tissue has been removed; especially is this so when the disease has progressed for a considerable time. If such happens the expense of treatment is altogether wasted, as the disease will continue and spread laterally.

After scraping, tar or other medium is frequently applied as a cover. Such covers frequently have an injurious effect, causing bleeding of latex and the formation of pads of coagulated rubber in the cortical tissue. Obviously this is not beneficial.

(*b*) Or no treatment at all is undertaken. In that case the tree will finally go out of tapping as quite useless, since there is every probability of the disease spreading round the tree, as well as downwards and possibly upwards: it will probably become heavily burred. Removal will be necessitated, and a supply even if successful would not come into tapping under four or five years, at which time it would yield an average for a tree brought into bearing the first year.

Experiments were tried on one estate by resting trees which had already been examined and found to be affected with Brown Bast on one section. On re-examination twelve months later the disease was found to have spread laterally and upwards into adjoining sections previously free.

On another estate trees seven years old (January, 1920) which had become "dry" and had become affected with Brown Bast during the first eight months of tapping were

rested. The trees were opened for tapping in November, 1917, and taken out of tapping in July, 1918. No further tapping had taken place when the trees were examined in January, 1920, and the disease was then found very deep-seated on the original section below the cut, and had spread into virgin bark on each side. In one case the disease had passed quite round the tree, and in some other cases the cortex was affected down to the tap root. The great majority of the affected trees were of more than average size in an area where development was very good indeed.

It has frequently been stated that in the case of Brown Bast, if tapping be discontinued, the disease does not spread. On the other hand, it is admitted that the tree does not affect a self-cure.

Reeve in First Ceylon Report, 1920, Rubber Growers' Association, states :—

> "I have not seen any tree definitely attacked by Brown "Bast cure itself. Even if much of the affected bark "scales off, the bark below will still be found to possess "the typical Brown Bast colour, although some of the "interior layers may yield a certain amount of latex" (and further), "sections of Brown Bast bark have been ex- "amined from trees rested for known periods, the longest "period being eighteen months, *i.e.*, they were not only "dry trees but had developed a slight brown discoloration "in the bark (the wound gum of Bobilioff). In all cases "where this brown discoloration had been present there "were no signs of recovery by resting, the discoloration "was still present and the trees were still non-laticiferous. "In one case where the tree had been heavily scraped and "tarred, new tissue had apparently formed, and the brown "discoloration was present in this, so that one is forced "to the conclusion that resting trees which are definitely "known to be Brown Bast infected is useless."
>
> "One such rested tree which has been under observa- "tion three years has neither scaled off the diseased bark "nor has it formed nodules, so that the tree is still un- "profitable, and likely to remain so."

We have seen cases of trees rested for periods of two, three, four, five, and six years but which still suffered from the disease. It is surely obvious that nothing is gained by resting the tree even if the disease does not spread.

Why not take out the diseased portion and continue tapping? The tree is useless in any case if it is not a revenue producer.

We have never seen a case of self-recovery by resting, but we have seen many cases where the area affected has increased both in area and in depth.

It should be noted that the claim for a rest cure is made only for *some* trees, but no method is outlined as to how these particular trees must be discovered. We can only assume, then, that by this treatment a percentage may be self-cured. Suppose that, after a resting period of, say, even three years (the shortest time suggested), a large percentage succeeded in throwing off all the affected tissue, can the operation then be considered financially sound? The crop from all the affected trees for a period of three years has been nil, whereas had treatment by stripping been promptly carried out, tapping could have been continued over the three years, an ample period to repay cost of treatment and leave a considerable margin. The longer the resting period is prolonged the greater must be the loss in revenue to the estate. Further, what has happened in the meantime to those trees which have not effected a self-cover? It will probably be found that many are now beyond treatment, and some will have become burred.

Even if some of the trees are now treated, the task will be much more difficult, the amount of cortex to be removed considerably greater, with a corresponding increase in cost per tree. There is nothing to be done now but take out the burred trees, *i.e.*, these trees have been simply an encumbrance to the estate for the resting period, three to five years, since they have produced no revenue.

Against these, presuming stripping is undertaken and is successful (not all cases will be successful, as it is highly probable that with stripping as with other methods of treatment recurrence of the disease will be found in a small percentage of cases due to the fact that not all the affected tissue has been removed), the regenerated cortex will be tappable in, say, four to five years. It should be noted, too, that tapping will be possible on a tree at least ten years old, as against a supply at five years old, and the tree need not be taken out of tapping; tapping may be resumed on the, as yet, unaffected portions of the cortex. There is no need to allow a resting period when treatment by stripping is carried out, *i.e.*, if any tappable bark remains.

At least by stripping the diseased tissue is removed, burring is prevented, and the spread of the disease is checked. We

have seen many cases where the diseased area had been stripped and tapping continued below: no resting period was allowed, and the tapping had continued on the side for periods varying from nine to eighteen months without any sign of the disease appearing on the sections in tapping. Regeneration of cortex over the stripped surface had proceeded rapidly, and excellent results are anticipated. Had such trees been left untreated there is every probability that the disease would have extended down to the tap root, laterals, or to other sections of cortex round the tree, and in some cases at least it is very probable that burring would occur.

In other cases where the whole of one section was stripped down to the lateral roots a fresh section was brought into tapping immediately, and after fifteen months there was no sign of the disease in that section. In the meantime the regenerated cortex in the treated area had attained an average thickness of four mm., and appeared quite healthy.

Assuming that in a small number of cases the disease recurs on the regenerated cortex previous to tapping even when all the diseased tissue had been removed, and this is exceedingly improbable, the remainder of the cortex has in the meantime been saved for tapping. We have not seen a case of recurrence of the disease in regenerated cortex after all the diseased tissue had been removed. Further, if the disease recurs after stripping, it is highly improbable that other and less drastic methods of treatment would have been successful.

Stripping.

In all cases the important point is to find the Brown Bast and treat it in the early stages. By doing so, the area to be stripped will be small (a minimum in fact), burrs will not be present, and stripping will usually be easy.

Young trees as a rule strip more easily than older ones, and virgin bark more easily than renewed bark. When, as shown by a few experimental cases, the operation is somewhat difficult, *e.g.*, there may be a liability to cracking of the bark, it is better to first scrape off all the outer bark from the part to be stripped. Sometimes the cortex is still difficult to strip without wounding the underlying cambium. In that case the best method is to remove the diseased tissue in longitudinal strips about one to two inches wide, using a thin sharp instrument for cutting the cortex into strips.

In stripping old trees (over eleven years) and where renewed

cortex is included, it has been found on some estates that stripping is facilitated if the cortex is first well scraped, then left for about a month or six weeks before stripping is undertaken. Excellent results in stripping even advanced cases on old trees have been achieved by first scraping moderately deep, and then stripping in two to three inch strips three months later. This is probably due to the fact that for a short time after scraping the rate of formation of new tissue from the cambium is considerably increased so that a thin band of new soft tissue is formed on the inside of the cortex.

On the great majority of estates little or nothing has been done as regards treatment of Brown Bast in the past, more especially in the older areas of rubber, except taking out badly burred trees. Before considering treatment in these old areas the question of thinning out should be taken into account. If this is decided on, a census of Brown Bast should be taken by a tree to tree examination. It will then be found that some of the cases are almost or quite impossible to treat, either because of burring having already started, or because the disease has penetrated through to the cambium. These extreme cases may be removed during thinning out and the remainder treated. The percentage of cases will in such areas probably be found to be high, simply because of the age of the trees and the fact that no treatment has been undertaken in the past; where it is low, this may be due to a judicious selection of Brown Bast trees in a previous thinning out programme.

The type of tree must also be taken into account when dealing with old rubber. Where renewal has been very slow or where the general characteristics indicate that development is poor, stripping will be found difficult and extremely tedious. The percentage of cases will, however, generally be considerably less than in areas where development and renewal are very good.

It is necessary to emphasise the fact that once stripping is undertaken all the affected cortex must be removed. If after taking off part of the cortex further diseased patches are revealed by the discoloration in section, it may be at a different depth in the cortex, more must be stripped until the whole of the diseased tissue has been removed. It may be found necessary, especially in older areas, to strip portions of the tap root and laterals. The affected tissue must not be left on any of these portions.

Usually the stripped surface does not require the application

of any medium unless wounds have been caused, and in no cases should even dilute mixtures of any fungicide, tar or tar oils, etc., be applied to the stripped surface, but if there be any danger of infection by Mouldy Rot, spraying with warm paraffin wax has been found the most beneficial procedure. Paraffin wax is the only cover which can be applied with any degree of safety. If the stripped surface is exposed to possible drying effect by direct sunlight, it is better to shade it for a day or two by screens; these should not be placed too near the surface, as very dense shade attracts some insects. A screen can be made of attaps and leaned on two sticks against, but not close to, the tree. Screens may be necessary for a short time to protect the stripped surface from the direct influence of very heavy rain. This does not apply if a wax cover is applied, as explained later. Screening, however, will usually only be necessary for trees near the edge of a field or division. Borers do not usually attack the stripped surface unless wounds have been made, and normally, regeneration proceeds very quickly. Stripping should not be undertaken during wintering or during a prolonged period of drought. Crickets have attacked stripped areas in some districts, but this pest appears to be very local. Removal of all litter, etc., from the base of the tree and spraying the ground and screens (if used) with kerosene is an efficient preventative.

Although the use of screens is mentioned here, we do not advocate their use unless it is found absolutely necessary, as there is always the possibility of numerous insects, some of which may cause injury, hiding beneath the screens.

The method adopted with success on some estates so as to carry out the operation at a minimum cost and obtain the best results is as follows:—

A small gang of coolies, say half-a-dozen, preferably coolies who have had experience in tapping, should be trained to diagnose the cases by careful examination of typical Brown Bast trees. This gang should then take a census of Brown Bast trees by making a tree to tree examination. Doubtful cases should be marked and examined afterwards by a competent European if possible. The oldest finished cut and the remaining tapped sections and section in tapping should be examined in turn by cutting into the cortex with a tapping knife, *i.e.*, the cortex all round the tree should be examined. By this means the affected area is roughly mapped out. A second small gang of coolies should then proceed to scrape the affected portions so

that only a thin skin (about twice the thickness of a banana skin) of the cortex is left.

During the scraping the affected cortex will be clearly revealed, and an area two inches outside this all round can be marked out, say, with a tapping knife. The second gang (scrapers) only deal with trees marked by the first as having Brown Bast. This second gang is followed by the three or four coolies who will do the actual stripping. The fact should be strongly emphasised that a stripped surface must not be touched in any way, as by so doing wounds are caused With a little practice such a gang of coolies will get through the work effectively at a cost of not more than thirty cents per tree, and possibly considerably less for the first itinerary. This first tree to tree examination, scraping and stripping, will be the most costly, as the areas of cortex to be removed will, on the average, be greater than in the second and succeeding examinations. Later the number of cases will be much smaller, the amount of cortex to be removed less, and the coolies will have become more expert in every way, so that the disease in ninety per cent. of cases will be discovered in the early stages. To make absolutely certain that the stripped surface is protected from the start, the strippers may be followed by a single coolie, who will spray the surfaces with paraffin wax. All he requires is a simple arrangement for carrying a small fire and pan containing the wax, and a garden syringe with a fine rose. One sprayer will keep up with three to five strippers. He should also shade portions—laterals, etc.—which might suffer from the effect of the sun on the paraffin wax.

After the initial tree to tree examination and all the cases marked in the first itinerary have been dealt with, the number of coolies on this work could be reduced to three or four. Later still, this or a smaller number will be able to deal with cases as they arise and are noted by the tappers. The number of cases to be dealt with during the first examination will depend on :—

(*a*) The age of the trees,

(*b*) Tapping systems,

(*c*) Past history,

i.e., whether the cases of Brown Bast have been previously treated or not.

Trees which have already become burred are in the great majority of cases beyond treatment. But if it is necessary to

retain a tree which is burred on one side only all affected tissue from the side free from the burrs should be taken off and the burrs removed. Wounds down to the wood, *i.e.*, beneath the burrs, should be tarred. Sometimes a considerable thickness of cortex has formed beneath the burr. In that case, if healthy (which is very doubtful), it may be left, but in any case a burred section will give a very uneven tapping surface. In the meantime a new cut may be opened in unaffected cortex above the burred section or on the side removed from it.

An actual example of an estate where complete treatment was undertaken may be quoted. This estate was on flat land where renewal was very good and growth very good. The trees were eight to thirteen years old.

1st. Itinerary revealed twelve to twenty-four per cent. of the trees affected with Brown Bast in different fields, a very large proportion being dry on at least one section. Cost of treatment throughout approximately thirty cents per tree. This was the all-in cost and included the census.

2nd. Itinerary revealed five per cent. of Brown Bast throughout. (This was eight months later, and probably included a small number of cases previously missed.)

3rd. Itinerary revealed one per cent. of Brown Bast. (This was four months after the second was completed.) The greater proportion of these were probably new cases.

On another estate over 12,000 cases have been treated by stripping in a manner similar to the above, and the work has been so well done that in not a single case has Brown Bast yet appeared on the sections now in tapping. Some of the trees were stripped all round to five feet from the ground, and the tap root and portions of laterals also were stripped. The regenerated cortex after nine to twenty months is in every case developing well, and for those cases over fifteen months old averages five to six mm. in thickness. The number of failures is so small as to be quite negligible, and in over ninety per cent. of the treated cases the recovery is perfect. In the case quoted the best results have been obtained by simply stripping and not making use of any after-treatment. Shading was not found necessary.

On some estates where very careful supervision and expert labour have been possible a combination method of deep scraping and stripping has been carried out in some cases, *i.e.*, scraping away the affected tissue where it is not too deep, and stripping the smaller deeper-seated tissue. The method is, however, of doubtful utility, since one can never be certain that in the scraped portions all the diseased tissue has been removed. Owing to its uncertainty in effect we do not recommend this form of treatment.

The figures given on p. 51 are quoted from an estate "D," where the work of Brown Bast was conducted on systematic lines. The manager who supplied the figures is quite satisfied with the excellent results of the work.

2ND AREA.

Field.	No. of Trees.	Brown Bast.	Percentage.
16	10,432	1,971	18·8
17	10,660	2,074	19·4
18	11,360	1,336	11·7
19	4,772	936	19·6
20	5,616	967	17·2

SUMMARY.

Total acreage	990
Total trees inspected	84,000
Total trees affected with Brown Bast ...	16,423
Percentage of Brown Bast	19·55

A further record of five other fields on the same estate was as follows :—

Trees inspected	42,840
Brown Bast	7,284
Percentage of Brown Bast ...	17

Estate "D" previously quoted will furnish a typical example of what may be the cost of resting trees affected with Brown Bast in the hope of a self-recovery after, say, three to five years.

Total area of estate = 1,500 acres, the whole of which is in bearing.

Total number of trees = 122,840.
Total Brown Bast trees = 23,707, which is 18·5%

TABLE OF BROWN BAST WORK ON ESTATE "D."

Field.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Acreage	108·85	66·25	21·25	11·13	65 85	130	154	155·15	220	58	18·17	12
Trees in field ...	7965	5587	1997	1114	5507	11296	12933	13710	21316	6619	1876	869
Trees inspected ...	7665	5587	1997	1114	5507	11296	12933	13710	17262	6619	1876	869
Trees cut affection	2297	248	339	7	594	188	1008	2783	731	229	96	248
Trees root affection	499	35	56	—	26	1894	145	51	1557	1059	3	7
Treescollaraffection	346	189	94	1	140	—	200	294	814	599	—	2
Total trees treated	3142	472	489	8	760	2082	1353	3128	3102	1887	99	257
Acreage finished ..	108·85	66·25	21·25	11·13	65·85	130	154	155·15	145	58	18·17	12
Per cent. of Brown Bast	39·45	8·4	24·5	·88	13·08	18·4	10·4	22·81	17·9	28·5	5·2	29·5

Root affection means those cases where the disease had passed down into the tap root or to laterals or both. It does not mean that the disease originated in the roots. Both collar and root affections, in the great majority of cases, most probably originated from a finished cut or from a cut which became wholly or partially dry.

This (18·5%) may seem a high figure, but is not exceptional for rubber eight to thirteen years old where no previous treatment has been carried out.

We will assume for this particular case that a complete resting period of three years would have been necessary in order to allow the trees to throw off the whole of the affected cortex.

Taking the annual yield per acre throughout to average 350 lb., the total loss of dry rubber during the three years would have been—

$$18{\cdot}5\% \text{ of } (1500 \times 350) = 3\left(\frac{1500}{1} \times \frac{350}{1} \times \frac{37}{200}\right)$$
$$= 291{,}375 \text{ lbs. in the three years.}$$

If we reckon the profits on the same basis as in recent flotations of rubber properties in Malaya, *i.e.*, at forty-five cents per lb., the loss in profits over a resting period of three years is

$$\$\ \frac{291{,}375 \times 45}{100} = \$131{,}118{\cdot}75$$
$$= £15{,}311,$$

or, reckoning on the more conservative estimate of a profit of sixpence per lb., there is a decreased profit of £7,284 for the three years' resting. In addition there is probability of burring in many cases, and also the very doubtful utility of the results being favourable in even a small percentage of cases.

Suppose instead of resting for this period (three years) all the cases had been treated by stripping at an average cost of, say, forty cents per tree, and the trees continued in tapping (the actual cost was considerably lower than this), the total cost of treatment would then have been—

$$\$\ \frac{23{,}707 \times 40}{100} = \$9{,}482{\cdot}80 = £1{,}106.$$

This means a gain by treatment and continuance of tapping on the basis of sixpence per lb. profit of £7,284 − £1,106 = £6,178 over the period of three years in profits alone, and on the basis of forty-five cents profit a gain by treatment of £15,311 − £1,107 = £14,204.

In addition there is the satisfaction of knowing that all the diseased tissue has been removed, burring has been prevented,

the spread of the diseased area has been checked and the trees continued in tapping.

Even if there is a slightly reduced yield of latex when the regenerated cortex again comes into tapping after four to five years, this is much more than compensated for by keeping the trees in tapping through the three to five years as against resting.

All the cases have been treated with excellent results. None of the treated cases show signs of burring. No treated trees have again become dry (November, 1919). Approximately 12,000 of the treated cases are now in tapping, yielding a normal amount of latex for alternate daily tapping on a single V for the age of the trees.

The greater portion of these trees were rested for periods of three to six months after stripping.

In the same district and in the immediate neighbourhood of the estate quoted above, there are many native holdings which, so far as type of land and soil conditions are concerned, are exactly similar. No treatment has been undertaken, and the percentage of burred trees is very high, while the percentage of Brown Bast trees averages nearly thirty per cent., and in a few cases considerably exceeds this figure.

In about forty small native holdings in this district the average percentage of Brown Bast ranged from seven to forty-two, the majority lying between 22 per cent. and 32 per cent.

A case may be quoted here of a field of old rubber (twelve to thirteen years) which had been subjected to very heavy tapping. At different periods as many as six cuts had been tapped daily; three cuts tapped twice daily; three cuts on one quarter tapped daily; two V's on one half superimposed tapped daily; and, last, a single V on one half tapped alternate daily. The first tree to tree examination revealed forty per cent. affected with Brown Bast and over thirty per cent. of the trees were dry. The number of trees per acre had been reduced to eighty-five, so that the taking out of all affected Brown Bast trees and burred trees was out of the question. The number of burred trees was about eight per cent., and these were taken out, until finally only 75 trees per acre were left.

All remaining cases (except one) were treated by stripping, and the results to date are excellent (15 months after treatment). The single case left untreated has commenced to form burrs. The whole field is again in tapping, and now yields over four hundred lbs. per acre per annum (tapping alternate daily). In

no case has Brown Bast appeared on the new sections of the treated trees after tapping for six months. Some of the trees which were stripped all round to a height of three to five feet are, of course, not being tapped, but the regenerated cortex is doing well, and it is estimated by the Manager that these will be tappable in four years, and probably sooner.

If this field had not been treated it is highly probable that forty per cent. of the trees would have been entirely lost as revenue producers. The cost of treatment averaged less than thirty cents per tree.

On an estate "C" over seventeen thousand trees were stripped for Brown Bast. In some cases burring had already commenced, rendering the operation much more difficult. The work was well done at a cost of about twenty-five cents per tree treated. After treatment the trees were rested for periods varying from six to twelve months. Twelve thousand of these trees are at present in tapping, and have been tapped alternate daily for three to nine months. None have to date developed Brown Bast on the sections in tapping. The remainder will be opened for tapping as soon as possible. In practically every case the regenerated cortex is developing well and is in excellent condition. Some of the trees were stripped entirely from a point three feet to five feet above ground to half-way down the tap root and along one or more laterals. In some cases the regenerated cortex was treated with a tar preparation about six months after stripping, but the best results were obtained by simply leaving the stripped surface even in areas where the number of trees per acre averaged less than eighty. The estate is situated on flat land where the normal growth is very good, and bark renewal is also very good, while the rainfall is about one hundred inches per annum.

The Manager of estate "F" writes :—

> "Stripping was carried on throughout 1918 and 1919.
> "Approximately four thousand trees were treated, and in
> "every case the renewal has been both healthy and rapid."

The following figures are from an estate "G," part of which is on flat land where the soil is poor and the growth backward, the remainder is undulating and very variable in character of soil, a portion producing trees of above average for age. Treatment of Brown Bast was commenced some three years ago, where possible by stripping. In the area where growth was poor, the trees have thin hard bark and treatment

by stripping eleven years old rubber was found practically impossible. Deep scraping with a view to subsequent stripping was of necessity resorted to. Where possible these cases were later stripped, and retreatment was found necessary on many scraped cases which could not be stripped. The treatment of Brown Bast is now part of the ordinary routine pest-work on the estate, a small gang of coolies being kept for that work alone. Now that the work is well in hand the area to be stripped is usually small. Special attention is paid to the young rubber, so that the cases are diagnosed and treated in the early stages with excellent results.

ESTATE "G."

I.

Field 183 Acres.

Round No.	Commenced.	Finished.	New Trees.	Re-treated.
1	June 14, 1917	July 22, 1917	1,029	
2	Aug. 3, ,,	Aug. 12, ,,	171	
3	Aug. 22, ,,	Aug. 27, ,,	88	
4	Sept. 6, ,,	Sept. 11, ,,	79	
5	Oct. 1, ,,	Oct. 8, ,,	96	
6	Nov. 1, ,,	Nov. 7, ,,	105	
7	Dec. 1, ,,	Dec. 7, ,,	119	
8	Dec. 24, ,,	Jan. 31, 1918	680	1,303
9	May 13, 1918	May 27, ,,	1,167	84
10	July 20, ,,	July 29, ,,	244	67
11	Aug. 13, ,,	Aug. 26, ,,	194	64
12	Oct. 8, ,,	Oct. 27, ,,	258	172
13	Jan. 26, 1919	Feb. 19, 1919	757	121
14	April 8, ,,	April 24, ,,	484	52
15	May 26, ,,	June 9, ,,	194	57
16	July 12, ,,	July 21, ,,	244	31
17	Aug. 29, ,,	Sept. 8, ,,	352	50
18	Oct. 23, ,,	Nov. 29, ,,	372	37
19	Dec. 9, ,,	Dec. 28, ,,	620	83
20	Feb. 15, 1920	Feb. 29, 1920	559	43
			7,812	2,164

II.

Field 112 Acres.

Round No.	Commenced.	Finished,	New Trees.	Re-treated.
1	July 23, 1917	Sept. 26, 1917	1,861	
2	Oct. 9, ,,	Oct. 18, ,,	220	
3	Nov. 10, ,,	Nov. 17, ,,	90	
4	Dec. 7, ,,	Dec. 24, ,,	456	
5	Feb. 1, 1918	Mar. 10, 1918	418	1,458
6	May 27, ,,	June 12, ,,	767	258
7	July 29, ,,	July 31, ,,	131	15
8	Aug. 23, ,,	Sept. 4, ,,	187	57
9	Oct. 27, ,,	Nov. 28, ,,	306	357
10	Feb. 19, 1919	Mar. 10, 1919	519	79
11	April 25, ,,	May 8, ,,	425	72
12	June 10, ,,	June 19, ,,	327	37
13	July 21, ,,	July 31, ,,	268	37
14	Sept. 9, ,,	Sept. 18, ,,	274	32
15	Nov. 4, ,,	Nov. 15, ,,	313	37
16	Dec. 28, ,,	Jan. 14, 1920	536	63
			7,098	2,502

III.

Field Bungalow Hill (106 Acres).

Round No.	Commenced.	Finished.	New Trees.	Re-treated.
1	Sept. 27, 1917	Nov. 24, 1917	1,256	
2	Mar. 19, 1918	April 22, 1918	775	775
3	June 7, ,,	July 7, ,,	663	439
4	Aug. 1, ,,	Aug. 5, ,,	100	29
5	Sept. 4, ,,	Sept. 17, ,,	178	78
6	Nov. 28, ,,	Jan. 14, 1919	373	294
7	Mar. 10, 1919	Mar. 27, ,,	498	68
8	May 8, ,,	May 18, ,,	313	53
9	June 19, ,,	June 27, ,,	268	39
10	July 31, ,,	Aug. 11, ,,	270	36
11	Sept. 19, ,,	Oct. 1, ,,	304	41
12	Nov. 19, ,,	Nov. 25, ,,	279	34
13	Jan. 15, 1920	Jan. 30, 1920	450	34
			5,727	1,920

IV.

Field "C" Division (56 Acres).

Round No.	Commenced		Finished.		New Trees.	Re-treated.
1	Nov.	25, 1917	Dec.	12, 1917	673	
2	April	4, 1918	May	12, 1918	597	552
3	July	8, ,,	July	11, ,,	000	7
4	Sept.	17, ,,	Sept.	30, ,,	105	33
5	Dec.	21, ,,	Jan.	20, 1919	152	90
6	Mar.	26, 1919	April	3, ,,	195	29
7	May	19, ,,	May	23, ,,	149	30
8	June	28, ,,	July	3, ,,	123	22
9	Aug.	12, ,,	Aug.	16, ,,	119	16
10	Oct.	2, ,,	Oct.	11, ,,	181	16
11	Nov.	25, ,,	Dec.	3, ,,	199	22
12	Feb.	1, 1920	Feb.	7, 1920	180	13
					2,673	830

V.

Field 6th Mile (44 Acres).

Round No.	Commenced,		Finished.		New Trees.	Re-treated.
1	Dec.	12, 1917	Dec.	23, 1917	380	
2	July	11, 1918	July	20, 1918	172	61
3	Aug.	10, ,,	Aug.	12, ,,	72	12
4	Oct.	1, ,,	Oct.	8, ,,	84	9
5	Jan.	20, 1919	Jan.	25, 1919	161	39
6	July	9, ,,	July	11, ,,	81	12
7	Aug.	25, ,,	Aug.	28, ,,	87	17
8	Oct.	18, ,,	Oct.	22, ,,	72	7
9	Nov.	30, ,,	Dec.	1, ,,	23	—
10	Dec.	7, ,,	Dec.	9, ,,	96	13
11	Feb.	11, 1920	Feb.	14, 1920	118	10
					1,346	180

VI.

Field 16 Acres.

Round No.	Commenced.	Finished.	New Trees.	Re-treated.
1	July 23, 1917	Aug. 2, 1917	116	
2	Aug. 29, ,,	———	9	
3	Sept. 14, ,,	———	4	
4	Oct. ,,	———	nil	
5	April 30, 1918	May 3, 1918	103	97
6	July 9, ,,	July 10, ,,	15	—
7	Sept. 25, ,,	Sept. 27, ,,	37	2
8	Jan. 16, 1919	Jan. 17, 1919	34	9
9	April 1, ,,	———	23	5
10	May 23, ,,	———	20	—
11	July 2, ,,	July 3, ,,	14	—
12	Aug. 15, ,,	———	11	—
13	Oct. 12, ,,	———	16	—
14	Feb. 5, 1920	Feb. 6, 1920	36	3
			438	116

VII.

Field "A" and "B" Division.

Round No.	Commenced.	Finished.	New Trees.	Retreated.
1	May 2, 1919	May 23, 1919	55	
2	July 4, ,,	July 8, ,,	121	3
3	Aug. 16, ,,	Aug. 25, ,,	201	4
4	Oct. 12, ,,	Oct. 18, ,,	136	8
5	Dec. 3, ,,	Dec. 6, ,,	121	10
6	Feb. 8, 1920	Feb. 10, 1920	98	6
			732	31

VIII.

Summary.

	Treated		Re-treated.		Acres.
	7,812	...	2,164	...	183
	7,098	...	2,502	...	112
	5,727	...	1,920	...	106
	2,673	...	830	...	56
	1,346	...	180	...	44
	438	...	116	...	16
	732	...	31	...	?
Total	25,826	...	7,743	...	527

Estate "G."

The total number treated includes the trees treated by stripping and those treated by deep scraping. Where stripping was difficult or impossible owing to age or type of tree the paring (scraping) method was employed with a view to subsequent stripping.

The great majority of retreated cases are : —

1. Trees scraped and finally stripped.
2. Scraped trees which later were found to be still affected and were either

   (*a*) Re-scraped,

   or

   (*b*) Finally stripped.
3. A few cases stripped which later developed Brown Bast on new sections in tapping. Of the cases both scraped and stripped, these form a very small proportion.
4. A few cases stripped where it was found on re-examination that all the affected tissue had not been removed in the first instance.

A small number of the trees first stripped are now being tapped on regenerated cortex (three years old), and more will be tapped over in the near future.

The amount of latex and dry rubber from these is quite satisfactory, and the quality of the rubber comparable to that from normal renewed cortex.

The Manager is quite satisfied with the results, and the systematic work is now being carried on as part of the estate routine. All treated and re-treated trees are in the tapping round, except a few of original cases stripped all round some two and three-quarter years ago.

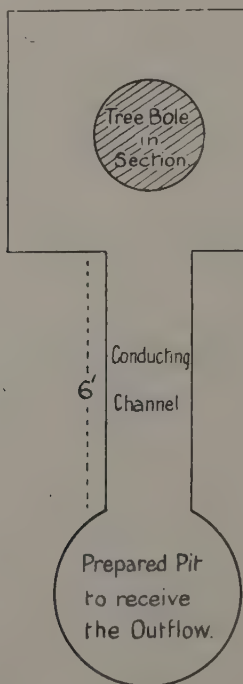
Tap Root Affections.

When examining the cortex for Brown Bast, it is frequently found, especially in old cases, that the disease has extended below ground on the tap root. The root system should be opened up and all the affected tissue removed by stripping. Wounds on the root should be tarred at once.

If paraffin wax is used as a cover, tarring is not necessary at this stage, as the wax forms an efficient cover to the wound.

When the wax is removed, however, the wounds should then be tarred. The tap root and portions of laterals should be left bare for some time, and a short channel dug from the trench round the base of the tree to conduct the water away from the tap root to a prepared pit some six feet away. On flat lands where the water table is high the channel will not exceed eight to ten inches, and the pit to contain the outflow will need to be about one foot six inches deep.

On land where the natural drainage is good only a conducting channel is required to prevent lodgment of water round the stripped tap root.



Application of Paraffin Wax.

It is necessary to point out that stripping not followed by some after treatment, *i.e.*, the application of a protective cover to the stripped surface, is not invariably a success. There have been cases where the stripped surface has been attacked by various insects, especially crickets, which nibble off the regenerated cortex during the first few days. If small wounds

are made there is further liability to attack by borers, and even if regeneration of the cortex is perfect for the first period of five to eight days, and then follow a few days during which the new cortex is kept continuously wet, the tissue is then liable to attack by certain species of fungi, which may destroy the cortex down to the wood. In "Mouldy Rot" areas there is the probability that a large percentage of the stripped areas will be attacked by this disease, if the surface is not protected as soon as possible by a covering layer, which will prevent access of the fungus. Paraffin wax is the best cover for this purpose. In no case should disinfectants, tars, or tar mixtures even in dilute mixture, be applied to the stripped surface, as by so doing the tissue is killed and large wounds are caused. Usually, however, these remarks apply only to a small percentage of cases, and any danger could be obviated by the application of paraffin wax.

This operation is conducted as follows :—

One coolie can keep up with three to five strippers. He carries round a simple apparatus by means of which the wax can be kept in a liquid state. The remainder of the apparatus consists of a supply of solid wax and an ordinary garden syringe fitted with a fine rose. As soon as the tree is stripped, the coolie with the wax, etc., draws the melted wax several times into the syringe and ejects it, to warm up the metal, and as quickly as possible, holding the syringe six to eight inches away from the stripped surface, proceeds to cover the exposed surface with a fine spray of melted wax, *i.e.*, melted while in the syringe, but which solidifies immediately on touching the stripped surface. The whole operation takes less than two minutes on the average.

One can easily determine when a complete cover has been applied by the dull appearance, as opposed to a wet, shiny appearance all over the surface. The temperature of the wax cover on the surface immediately after application is not appreciably higher than that of the surrounding atmosphere. As regeneration proceeds, by the end of three months, say, the wax gradually scales off. This should be collected, melted, and strained through a fine linen cloth, and may be used over again. There will, of course, be a little loss, but the cost of collection and making ready for re-using is extremely small.

If a sprayed surface is in such a position that the direct rays of the sun may fall upon it (this applies especially to lateral roots), there is the danger of the wax melting and

penetrating to the cambium; where such possibilities are apparent, the surface may be easily protected by a screen of simple construction leaned against the tree. The application of wax cover properly done ensures the surface completely against both fungoid and insect attack, and at the same time protects it from the direct action of heavy rain. The average cost per tree is exceedingly small, as but a small quantity of wax is used, and the operation is rapidly carried out (see plate 21 of apparatus). Stripping followed by application of paraffin wax has recently been carried out in some areas where "Mouldy Rot" is prevalent. In no case has "Mouldy Rot" attacked the stripped surface. Application with some form of fine syringe is much safer than the use of a brush or cloth. Care should be taken that the temperature of the melted wax is not too high, *i.e.*, the wax should not be bubbling preparatory to boiling, nor should it be emitting a large quantity of vapour or crackling.

General Observations.

There is a very large variation in the percentage of Brown Bast even in trees of the same age in different parts of the Malay Peninsula. It is difficult, however, more especially with the older estates, to make a reliable comparison, as the number of burred trees and Brown Bast trees removed during thinning out in the past is a variable factor. A truer comparison can be made with some of the younger areas, but even in these cases correct data is not always accessible. The same holds good when comparisons are made as regards tapping systems (periods) and the incidence of Brown Bast. Many estates have of necessity (shortage of bark, etc.) changed their tapping periods more than once, so that figures which are quoted should not be relied on unless the complete history of the areas compared is available.

The rate of spread of the disease is a most variable factor, and this also applies to burring, but at the same time we should not care to say that burring is restricted to particular areas, for so far as we can see, the district can have little or no effect on burring, either in aiding or retarding it. It seems to us that burring depends rather on factors connected with the incidence of the disease, and beyond the fact that under certain conditions, as applied to the cell, burrs are formed, we really know nothing, just as we do not know exactly what are

the governing factors in determining the formation of woody tissue from the cambium.

Burrs are rarely found in Brown Bast cortex on lateral roots below ground, though we have occasionally found small ones in such a position.

Brown Bast is rarely noticed first in tapped cortex, while the section is in tapping, *i.e.*, above the tapping cut, and when found there some considerable time afterwards a connection can generally be traced to a previously finished section, or to a point in untapped bark in an adjoining section in tapping.

In some cases burr formation follows quickly on the incidence of the disease, and fusion of the burr with the normal woody tissue takes place equally quickly. The growth inwards from the burr frequently follows the line of a medullary ray in such cases.

So far as our experience goes, borers do not attack Brown Bast cortex unless it has been scraped, and in very few cases (and those probably where wounds had happened) have we heard of borers attacking a stripped surface. Some few cases have been reported from time to time, but on investigation it was found that the exposed cambium had been previously killed by the application of some disinfectant, etc.

General Summary.

Considering, as we do, that Brown Bast is physiological in origin, it must be regarded in the first instance rather as an abnormality than as a disease, though the one state may lead to the other owing to interference with the functions of a portion of the tissue. The theory as to the physiological origin of Brown Bast is by no means new. Bateson, so long ago as 1913, was the first investigator to suggest a physiological origin of the disease. Several investigators since that time have put forward views more or less similar as to the disease being physiological in origin. At the same time this is the first attempt to describe in detail the peculiar structure of Brown Bast cortex and to formulate a theory by which the facts as observed can be explained. The facts themselves as regards effect on cortex, spread, etc., of the disease determine the line of treatment advocated. We do not, however, say that scraping, for instance, whether deep or light, may not be effective in some cases. That is quite possible. The real difficulty is to determine which cases should be so treated, and that could only be determined by microscopical examination of the affected

tissues in each individual case, an obviously impracticable proceeding.

The operation of tapping being considered the prime cause, it follows naturally that any individual Hevea tree which is subjected to tapping for the purpose of extracting latex will also be subject to development of Brown Bast, but it does not necessarily follow that every tree in tapping will develop Brown Bast.

Up to a certain age one may consider that the tendency to develop Brown Bast will not only always be present, but may even increase, and yet at the same time there may be individual trees which no matter for how long a period they were tapped would not develop Brown Bast.

Preventive measures cannot be laid down, and until much work on selection has been carried out there cannot be brought forward any evidence as to the hereditary character of the susceptibility to the disease. Areas under alternate daily tapping may, and probably will, usually show a smaller percentage of cases than areas under daily tapping, other conditions being equal, and reduction measures rather than preventive measures may follow these lines, *i.e.*, an increase in the period between successive tapping operations will tend to reduce the number of cases over a given period of time.

At the same time one must consider the question of treatment already outlined, and the final decision as regards alteration of tapping periods in connection with treatment rests on financial considerations, which must be settled by the manager.

Once the work is taken in hand the cost of treatment is comparatively low and should decrease; finally Brown Bast treatment will form part of the ordinary routine of the estate.

Any form of treatment cannot from the nature of the disease be considered as permanently curative in effect, since when a regenerated cortex is brought into tapping again under the same system as previously practised, there will be always the liability for the disease to recur. This, however, will be a new inception, and the rest of the cortex has in the meantime been saved.

The disease may have already appeared in other sections and if so the diseased tissue must be removed from these sections. There can be no finality in any method of treatment of a diseased condition, which is the direct result of an operation that is continued during, and immediately after, what one must term the temporary curative treatment.

As the estate increases in age the necessity for treatment will be bound to increase, since the present practice of taking out all Brown Bast trees cannot continue for an indefinite period.

On many of the older planted areas the time has already arrived, or will come in the near future, when the thinning-out process cannot be advantageously continued, hence in these cases the Brown Bast trees must be treated, *i.e.*, unless they are already beyond treatment. In any case the new affections as they occur must now be considered, and stripping, properly carried out, is both the easiest, most effective, and least expensive. Care is required in training the coolies in the first instance. On the younger areas the work of treatment should be taken in hand at once. Many trees will be retained for tapping and burring prevented.

Stripping as a form of treatment for Brown Bast has been frequently condemned as being too drastic. The expression is unfortunate and will not bear examination. Cutting off a big branch for Pink disease or removal of one or more laterals in treatment of root disease is a common and necessary proceeding. This is far more drastic treatment than the removal of even a large piece of cortex. Further, stripping is recommended as a cure for Brown Bast and to stop the spread of the disease, and no other form of treatment is likely to be generally effective.

The time is rapidly approaching when Brown Bast treatment will become part of the ordinary routine work of the estate just as weeding is now. On some estates the time has already arrived.

A. R. SANDERSON.
H. SUTCLIFFE.

THE RESEARCH LABORATORY,
Pataling,
Selangor, F.M.S.

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Rubber and Rubber Planting.—R. H. Lock.

APPENDIX.

"Dry" Trees.

The term "dry" has been applied somewhat loosely to Hevea trees which :—

(*a*) Have shown a considerable decrease in yield.
(*b*) Have ceased to yield.
(*c*) Have continued to yield fairly well from a portion of the cut measured in either length or depth.

Completely dry trees, *i.e.*, trees which yield no latex at all from any portion of tappable cortex, when tapped are not common, and form only a very small percentage of the total trees.

By far the larger proportion of so-called "dry" trees exhibit this condition in only one or two panels, and the majority of these are not completely dry, even in one section. They may yield a quantity of latex for which it is unprofitable to tap.

In some cases (quite a large proportion usually) such dry condition is only temporary, while in other cases it may become permanent, and gradually extend from one sector to others on each side. A tree may quickly recover from temporary dryness by resting, if Brown Bast is not present; where the dry condition, either partially or wholly, is due to Brown Bast, no such recovery results by resting.

Temporary dryness not due to Brown Bast in the first instance is probably directly connected with frequency and severity of tapping. Several factors play a part in this.

(*a*) The withdrawal of a fluid (latex), consisting largely of water (usually over 50 per cent.).
(*b*) The effect of this withdrawal on the latex vessels, *i.e.*, the fluid flows from the latex vessels at an abnormal rate owing to pressure released.
(*c*) The condition of the latex vessel must at some period, even if only for a short time, be altered by the withdrawal of latex, *i.e.*, the turgidity must be temporarily reduced at some point, or it may be over a considerable section.
(*d*) This must be compensated more or less rapidly, necessitating a considerable dilution of the contents of the latex vessels.

(*e*) The deficiency owing to withdrawal is made good by the increase in the water content (addition of water) of the latex.

(*f*) Such additional water must be passed in partly or wholly from the tissue surrounding the latex vessels.

(*g*) There is obviously a limit to the rate at which this can be supplied, depending to some extent on external conditions as regards moisture, etc., on which the turgidity and activity of the cortical tissues depend.

There may come a time in the life of most trees when a difficulty is experienced in making good the deficiency owing to withdrawal of latex. (The more frequent and severe the tapping the sooner is this difficulty to be expected.) Although the time between successive tappings is short (twenty-four hours), the tree may succeed up to a point in keeping the constitution of the latex and the turgidity of the latex vessels fairly constant.

It would appear that the turgidity of the latex vessel is closely related to that of the surrounding cortical tissue.

The fact that at each successive tapping the area from which latex is withdrawn is extended, obscures to some extent the effect of successive tappings on the constitution of the latex. Usually at some point, differing with the individual tree, a stage of equilibrium, or nearly so, is reached, when the composition of the latex is practically constant, *i.e.*, the amount of dilution necessitated is approximately counterbalanced by fresh reserves, so that the composition of the latex remains practically constant. (Weather conditions affect this temporarily.)

In some cases, especially approaching the base of the cut, a steady but small increase in caoutchouc content may be shown, but this rarely exceeds that for the first tapping, and never exceeds that for normal latex (first flow) from the same area. It may approximate this somewhat closely, however.

It is an established fact that from the first tapping onwards (intervals between successive tappings not exceeding six days) the percentage caoutchouc content of the latex gradually falls. The extent to which this takes place varies with individual trees. The decrease in percentage caoutchouc content is not altogether independent of the total yield of latex, whether measured wet or as dry rubber.

In general the volume of latex is in inverse proportion to the percentage caoutchouc, and it is apparently when these

reach their point of greatest divergence that there is the probability of a state of dryness succeeding, *i.e.*, an abnormal flow of weak latex may be merely the preliminary indication that the tree will become dry.

We may reasonably assume that in first tapping a tree, no matter what its age or the position of the cut, the latex which flows represents what is normal for that portion of the particular tree, and any change in constitution of the latex from successive tappings (the important factor that at each successive tappings fresh reserves are drawn upon, being of necessity left out of consideration) must be due to the withdrawal of latex.

Several investigators have carried out experiments on the effect of tapping on the caoutchouc content of the latex.

I. The figures are from Lock's experiments.

	1st tapping percentage caoutchouc.	Average percentage caoutchouc in succeeding 17 tappings.	Fall.	Lowest percentage caoutchouc.	Fall.
Daily	50	36	14	26 (17th tapping)	24
Alternate daily ...	50	41·7 (9 tappings)	8.3	36·1 (5th tapping)	13·9
Every third day ...	46	38·3 (6 tappings)	7·7	31·8 (6th tapping)	14·2

II. These figures are taken from Archief Voor de Rubber Cultuur in Nederlandsch India, June, 1918 (Dr. O. De Vries.)

DAILY TAPPING.	Percentage caoutchouc.	Average percentage first 17 tappings.	Fall.
1st opening ...	44·0	32·25	11·75
9th tapping ...	30·4	—	—
23rd tapping ...	24·2* (lowest percentage reached before trees were pollarded)		19·8

III. From Preparation of Plantation Rubber. Sidney Morgan. Half herring-bone system.

(a) DAILY.	Percentage caoutchouc.	Average percentage first 17 tappings.	Fall.
1st opening ...	31·9	24	7·9
6th tapping ...	23·3	—	—
25th tapping ...	18·47 (lowest percentage caoutchouc reached)		13·43

(b) ALTERNATE DAILY.	Percentage caoutchouc	Average percentage first 7 tappings over same period as above.	Fall.
1st opening ...	28·78	26·26	2·52
17th tapping ...	19·00 (lowest percentage caoutchouc content)		9 78

* At a later date, after pollarding the percentage sank to 20.

It is obvious from the foregoing figures that, as the percentage caoutchouc decreases, water (chiefly) must take its place. (This additional liquid contains for a considerable period a slightly higher percentage of organic matter.)

The comparatively large increase in percentage of water content of the latex can only mean that a more or less serious drain is made on the activity of the cortical tissue. If, however, the increased water content does not rise too high, and at a point remains practically constant (this actually occurs in the great majority of cases), it is probable that in the larger percentage of cases the tree may adjust itself to the changed conditions. Such, in fact, appears to be the case.

Exceptions, however, occur, *i.e.*, those cases where for some reason the previous adjustment breaks down and the necessary excess water is not forthcoming. When such occurs the latex either ceases to flow from all or part of the cut, or flows very slowly owing to the decreased turgidity of the latex vessel and the increased caoutchouc content. Frequently a mere button is exuded which quickly coagulates on the cut. In extreme cases the turgidity may fall so low that partial collapse of the vessels results, and portions of latex may be isolated.

It may be that if a large portion of liquid be passed into the latex vessel in an immature state as regards latex (caoutchouc) formation, the latex vessel may cease to function as such, and from that portion of the cortex no yield whatever is obtained, but instead only a very watery fluid is exuded. The difficulty in compensating for latex withdrawal is clearly increased as the intervals between successive tappings are reduced. It is probable that there is for each tree an optimum interval, *i.e.*, an interval between successive tappings which will yield the largest amount of latex with a minimum amount of drain on the cortical tissues. In general it would seem that twenty-four hours' interval (daily tapping) is too short for the trees to recover a condition approaching normal, so far as the constitution of the latex is concerned, and double that interval (alternate daily tapping) is on that account to be preferred.

Such would result in a smaller number of "dry" trees during any given period of time, while as has been publicly stated by a good authority, "The yield after a time would show only a small fall, and in fact might equal that under daily tapping."

A. This latter statement is made on the understanding that if the interval between successive tappings is doubled, the length of cut is also doubled. It is a

point frequently lost sight of in comparing daily with alternate daily tapping. On the other hand, when daily and alternate daily tappings are compared with cuts of equal length, *e.g.*, one cut on one quarter, all the evidence so far produced tends to show that daily tapping always give a considerably larger yield.

B. Another important point arises here with regard to doubling the length of the cut under alternate daily tapping. Assuming that eventually the yield approximates, or even equals, that under daily tapping half the length of cut, the latex would then be drawn from approximately twice the area of cortex, so that an amount of compensation equal to that by daily tapping, or somewhat less, would be spread over double the extent of cortical tissue, thus halving the drain all over. Doubling the time for recuperation would at the same time be of real practical benefit. Any condition obtaining in the cortical tissue which at any point tends to inhibit the passage of liquid into the latex vessels tends to produce or intensify a state of dryness. Such a condition is present in Brown Bast cortex, when in parts the latex vessels are surrounded by an actively dividing meristem. Such tissue tends to prevent the passage of fluids beyond its own limits, and may actually draw on the water in the latex vessels as well. If previous to the appearance of meristem tissue the latex vessels had already experienced a difficulty in obtaining the necessary extra fluid to compensate for withdrawal of latex, and later while this condition persisted there was added the second condition of Brown Bast, coagulation of latex in the vessels would quickly follow, possibly over considerable areas, and a rapid spread of Brown Bast condition result.

If, on the other hand, Brown Bast were not present the tree would quickly recover its yielding properties on resting. If Brown Bast were present the affected part would remain permanently dry.

PLATE 1.

A typical case of Brown Bast in a 15 years old tree. Heavy burring has taken place, necessitating the cut being raised to 5 feet and later to 6 feet. Treatment in the early stages at a cost of 30 cents would have enabled tapping to be continued near the base of the tree. Burring is still extending upwards at *a*.

PLATE 2.

Eleven years old tree with Brown Bast. Note the longitudinal cracks below the cut which has run dry. These cracks, preliminary to heavy scaling, are frequently typical of Brown Bast. Treatment at this stage is still possible, and profitable, though burr formation has commenced at A.

PLATE 3.

A.

B.

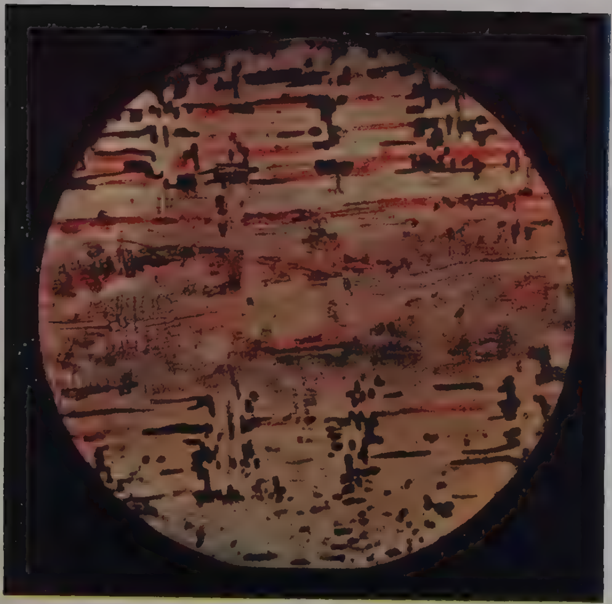
A. Early stage of burring in a thirteen years old tree.

B. Tree next to **A** treated by stripping.

A was not treated, and at the time showed no signs of burr formation.

It is still possible to treat **A,** remove the burrs and save the base of the tree for tapping. Failing treatment, the tree will most probably become like the one figured on Plate I.

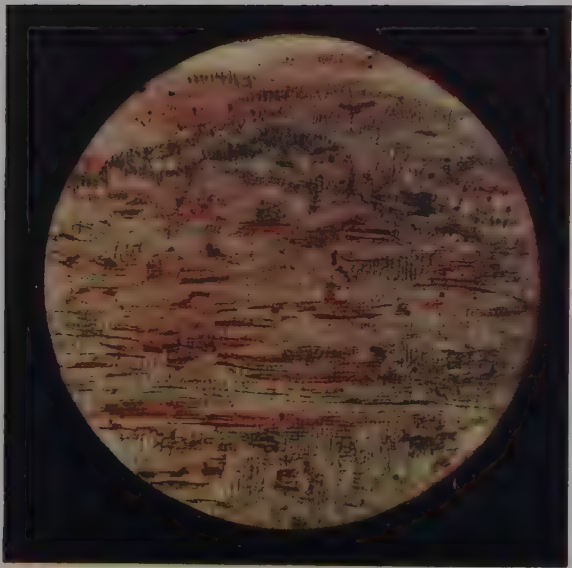
PLATE 4.



Longitudinal radial section of Brown Bast cortex showing a single broad zone of affected tissue. Note the displacement of latex vessels by the new tissue formation, as compared with the normal tissue on each side where the latex vessels lie parallel. At a later stage the whole of the cortex from just outside the innermost line of the Brown Bast band will scale off, but previous to that the disease will have passed to a deeper point in the cortex. The scaling plane is frequently characterised by an almost complete sheath of sclereides.

(Latex in latex vessels stained red with Sudan III. previous to being photographed.) $\times$ about 120.

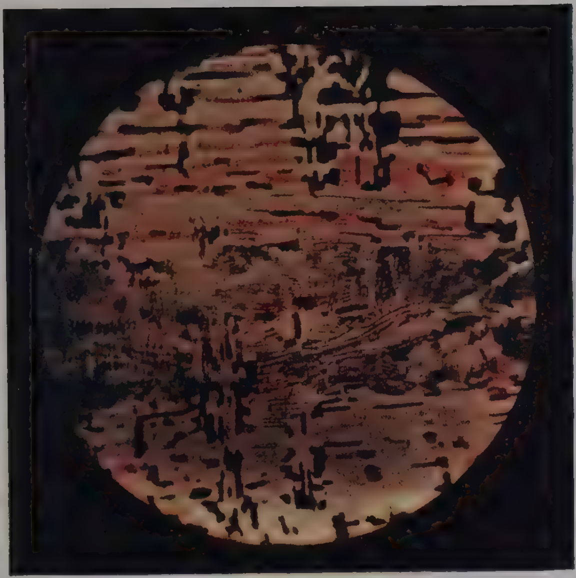
PLATE 5.



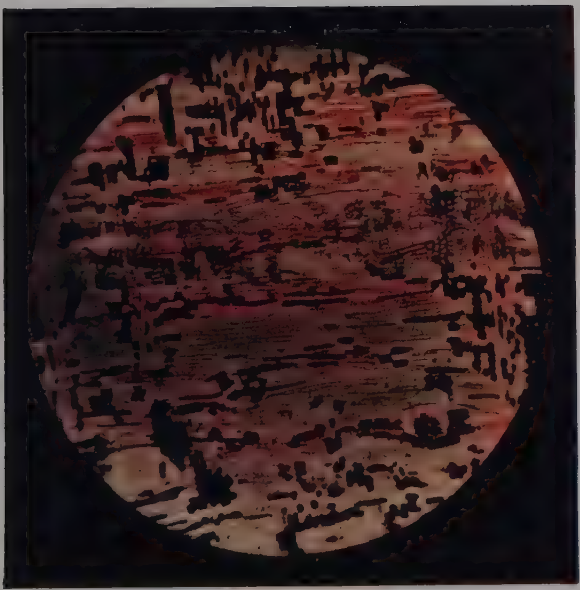
A similar, but more advanced case, and nearer the cambium than the one shown on Plate IV. × about 120.

PLATE 6.

A.



B.

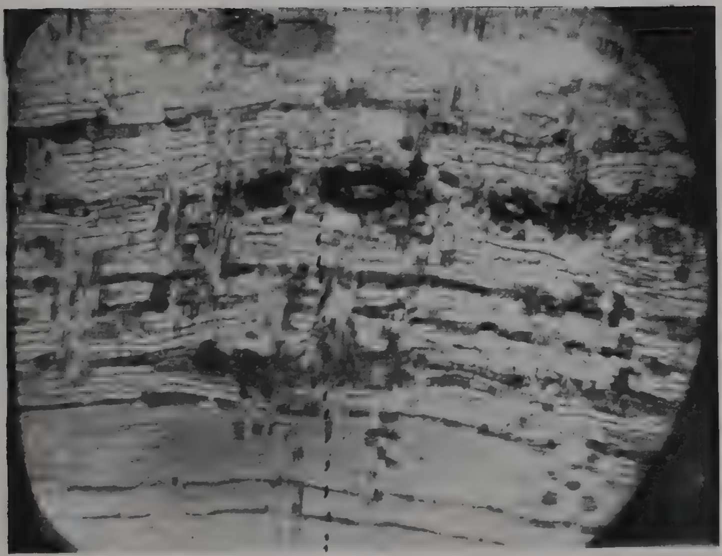


A. Longitudinal radial section of Brown Bast cortex in 8 years old tree "D."

Two zones of affected tissue were present of which only the outer one is shown, at a point where the second zone was not yet affected.

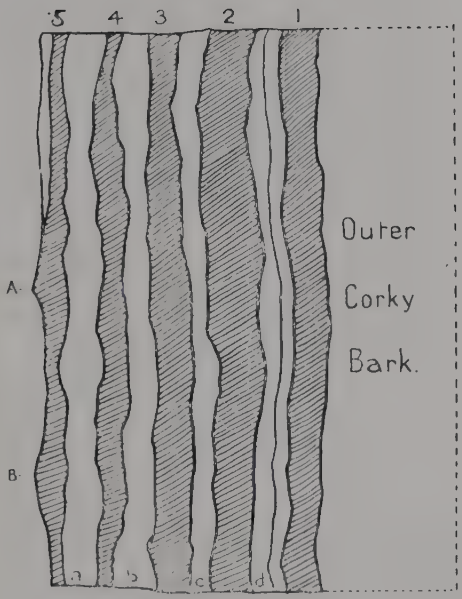
B. Section as **A,** but at a lower point showing both zones, the second one being quite near the cambium. × about 120.

PLATE 7.



Longitudinal section showing two zones *a* and *b*. *a* is the outer zone in which the disease probably originated, later passing inwards along the line *c* to a second cylinder of latex vessels *b* nearer the cambium. × about 120.

PLATE 8.



Brown Bast zones shaded

Diagrammatic representation of extreme case of zoning in Brown Bast cortex.

Diagrammatic representation from actual specimen of what is sometimes found in an advanced case where several zones of affected tissue are present. The figure represents a longitudinal radial section. The tree from which the specimen was taken was completely dry and had shown the first sign of the disease (fall in yield) twelve months previously. The two outer zones (1 and 2) could be easily pulled away along lines of cleavage parallel to the wood.

1-5, zones of Brown Bast; 1-4, discoloured (brown).

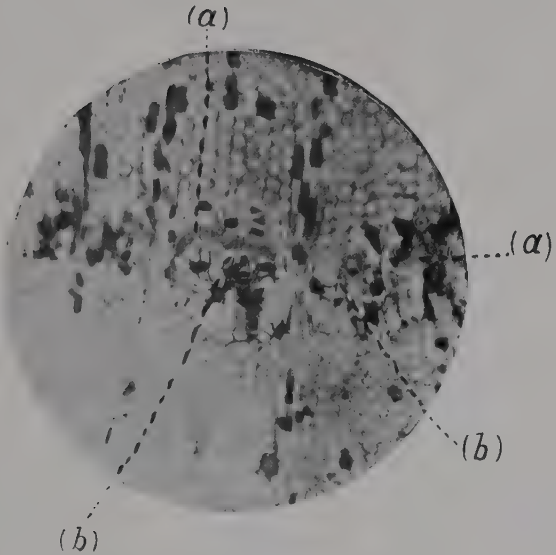
5, no discoloration visible except to the outer edge where thin yellowish brown streaks appeared.

A, B, meristem outgrowths impinging on the cambium and underlying wood, causing cavities due to pressure.

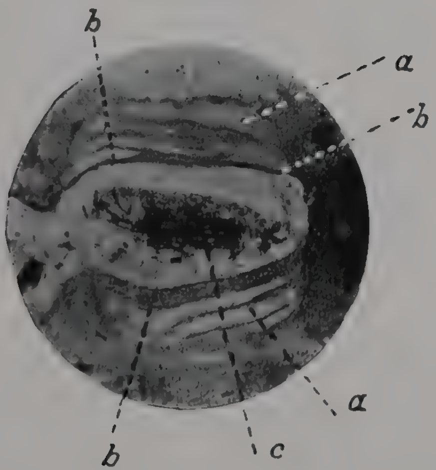
a, b, c, d, cork cambium formation by which zones would be eventually separated and scale off. Zones 1-4 much discoloured by tannin. Latex coagulated. Latex vessels displaced, broken, and portions isolated. *a, b, c, d*, intervals between zones contained many stone cells as also did zone No. 5. × about 5.

PLATE 9.

A.



B.

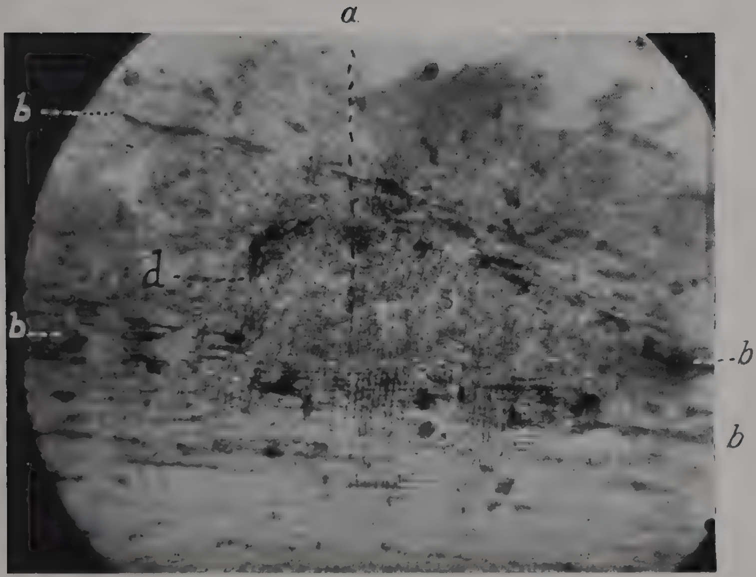


A. Transverse section, early stage of Brown Bast. Meristem formation has commenced in the vicinity of latex vessels at (*b*). Sclereides have already formed on the outer limits of the new tissue at (*a*). × 155.

B. A later stage than **A.** Note the large formation of stone cells *a* pushed out of place on each side. Much tannin is present in the vicinity of the latex vessel at *c*.

The line *b* is the new secondary meristem, the tissue inside this may later become liquified—the beginning of burr formation. × about 20.

PLATE 10.

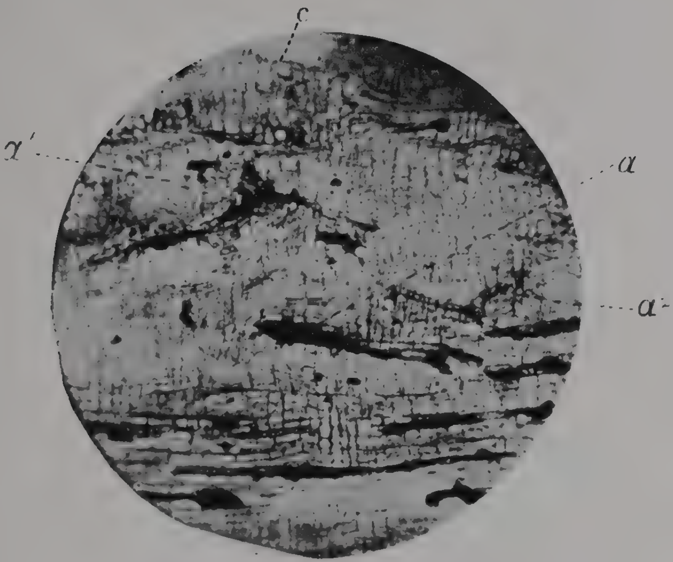


Longitudinal radial section of Brown Bast cortex from lateral root.

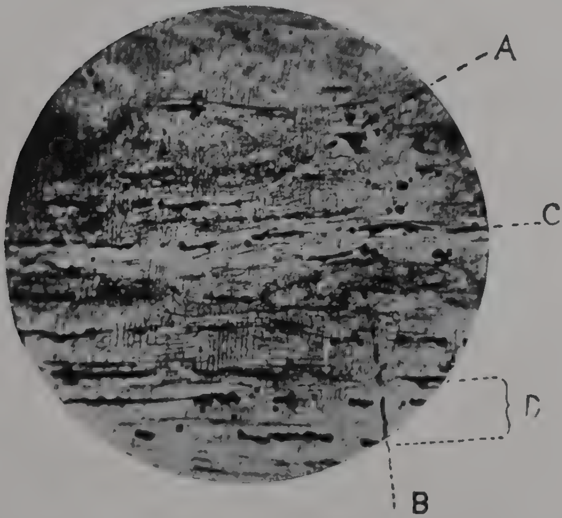
b represents cylinders of latex vessels which normally lie parallel, but here have been much displaced by the meristem tissue *a*. A portion of the inner cylinder has been turned through an angle of 90° at the point *d*. The latex in these vessels was probably coagulated at an early stage as there is little evidence of outflow though the vessels were ruptured. × about 60.

PLATE 11.

A.



B.

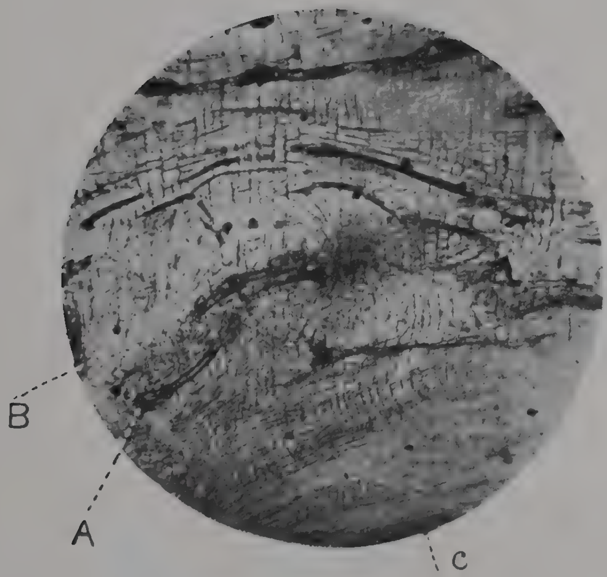


A. Longitudinal radial section of Brown Bast cortex showing displaced and broken latex vessels (a, a^1, a^2).

Latex has percolated into surrounding tissue at a^1, much new tissue formation is in evidence, as a and a^1 are parts of the same latex vessel and should lie in the same straight line. × about 60.

B. Longitudinal section of Brown Bast cortex. Two zones, A and B, are present, separated by a narrow zone C, as yet not affected tissue at this point. D is a second portion of normal tissue. Zones C and D would still continue to yield a small but gradually decreasing amount of latex. × about 60.

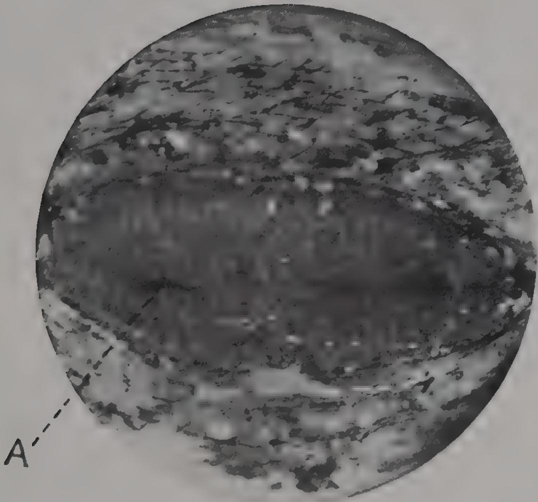
PLATE 12.



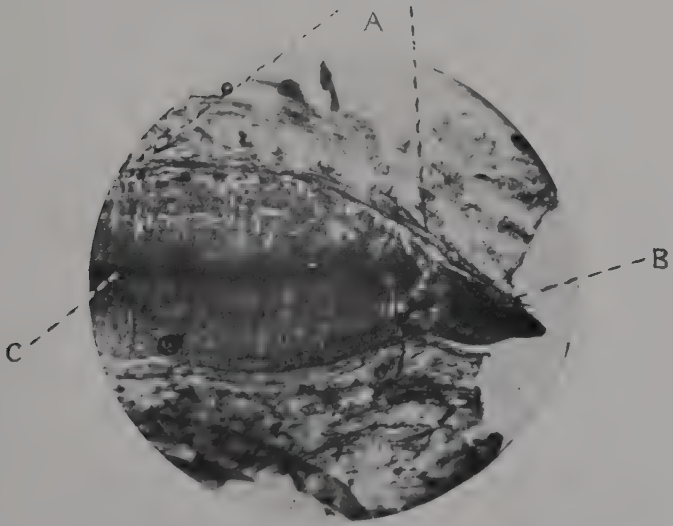
Longitudinal radial section of Brown Bast cortex. The vessel A has been broken at B and the parts displaced by new tissue formation. C indicates the direction of the cambium. × about 110.

PLATE 13.

A.



B.



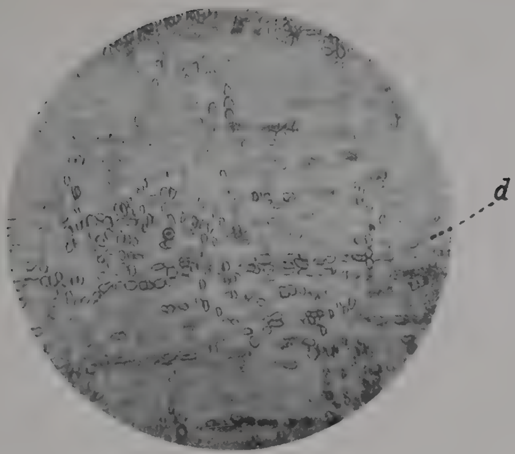
A. Longitudinal section of Brown Bast burr. Note A the course of the latex vessel through the centre. × 10.

B. Another section through the same burr.

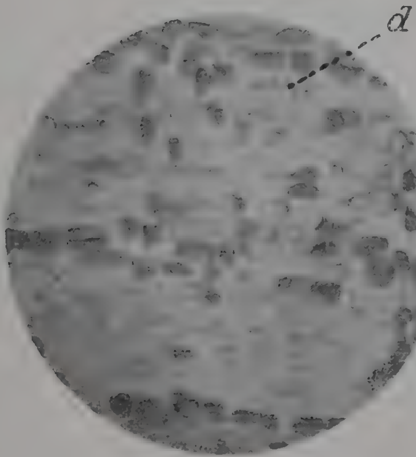
The portion A represents the first formed burr with latex vessel C along the centre. The burr is slowly extending along the same latex vessel in portion B but starting at successive centres. Finally this would tend to form one long burr along the course of the latex vessel. × 10.

PLATE 15.

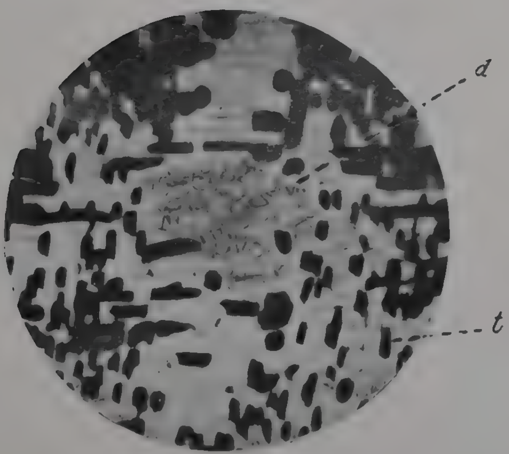
A.



B.



C.



A. General view of distribution of calcium oxalate *d* in Brown Bast tissue. × about 35.

B. Enlargement of portion of **A.** × about 100.

C. Small mass of crystals in cells which later would be converted into sclereides.

Note the presence of tannins *t* in cells surrounding. × about 90.

PLATE 16.

1 2 3 4

Serial photograph of Brown Bast cortex.

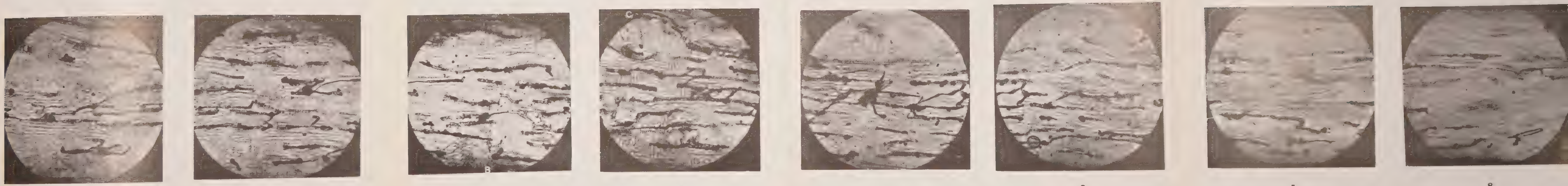
A-B is the affected zone lying quite close to the inner surface of the cortex. Note how the diseased zone decreases in width from right to left, *i.e.*, the disease was progressing in this case from right to left, the right being the upper edge of the longitudinal section. × about 60.

PLATE 17.

A.

1 2 3 4 5 6 7

B.



1 2 3 4 5 6 7 8

A. Longitudinal section of Brown Bast cortex, including the finished cut on the left, and from that point a portion vertically downwards.

A is the point of origin immediately behind the wound meristem on the finished cut. From this point the progress of the disease to the right (*i.e.*, downwards) is marked, portions of latex vessels being displaced and isolated.

Portions of tissue lying deeper in the cortex are being affected towards the right where the zone of meristem has greatly increased in width.

This was a case where the disease commenced well towards the outer cortex. × about 60.

B. Section of a more advanced case than **A,** showing distortion of tissue due to meristem activity. Latex vessels are much displaced instead of, as in normal tissue, lying parallel. Rupture of latex vessels is evident at B and C, etc. × about 60.

PLATE 18.

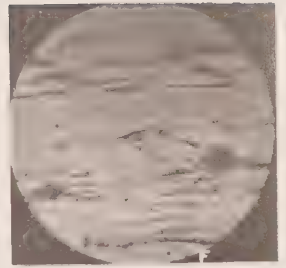
1

2

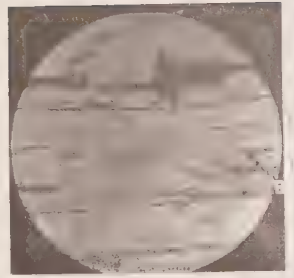
3

4

5



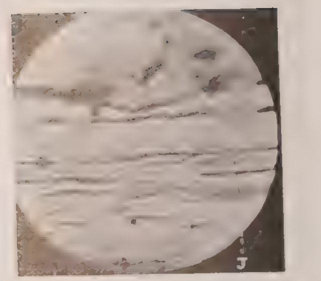
6



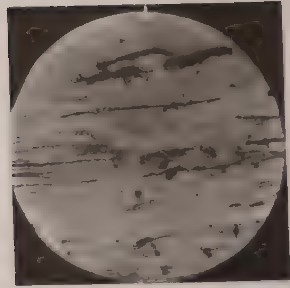
7

8

9



10

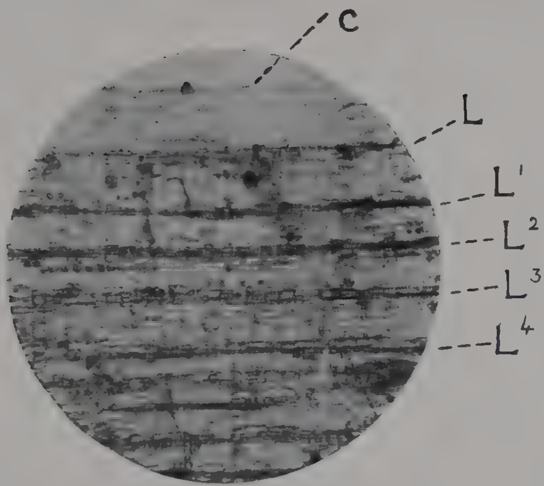


11

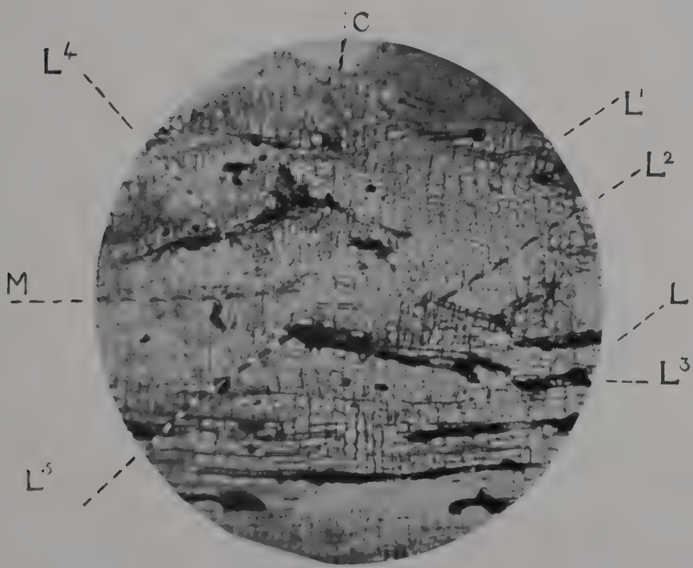
Serial photograph longitudinal section of Brown Bast tissue, a considerable length being shown
A **(No. 1)** indicates a ruptured latex vessel and the coagulated latex amongst the surrounding tissue
B **(No. 2)** is another point of rupture, the thick dark portions in the vicinity B' show where the intercellular spaces are filled with coagulated latex
C, D, and F are other parts where the latex vessels have been ruptured and the latex partly flowed out and coagulated.
E **(No. 5)** shows a small meristem development and latex vessels pushed out of position
G **(No. 7)** is a narrow zone of affected tissue. Small portions of coagulated latex B from ruptured vessels are distributed amongst the tissue
H **(No. 8).** The zone is obviously narrower here, and in the next photograph **(No. 9)** some of the latex vessels again lie almost parallel.
H² **(No. 9)** is a good example of rupture due to meristem tissue formation.
At J **(No. 10)** two of the vessels occupy their normal position. Other portions, K and L, are very badly affected. × about 60

PLATE 19.

A.



B.



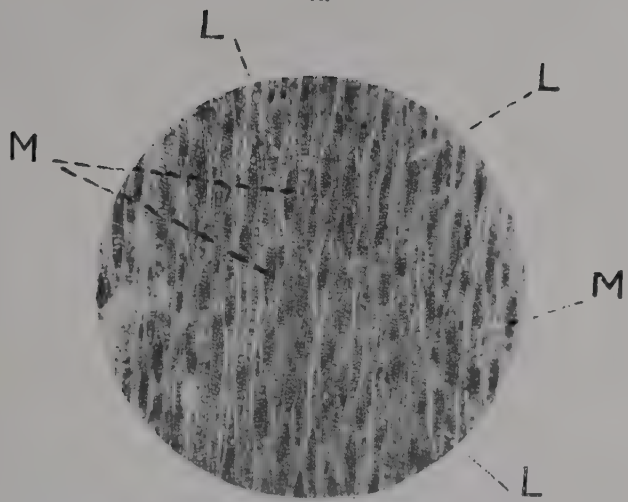
A. Longitudinal section normal cortex. Note the parallel courses of the latex vessels L, L[1], etc.

C is the innermost layer of cortex overlying the cambium. × about 60.

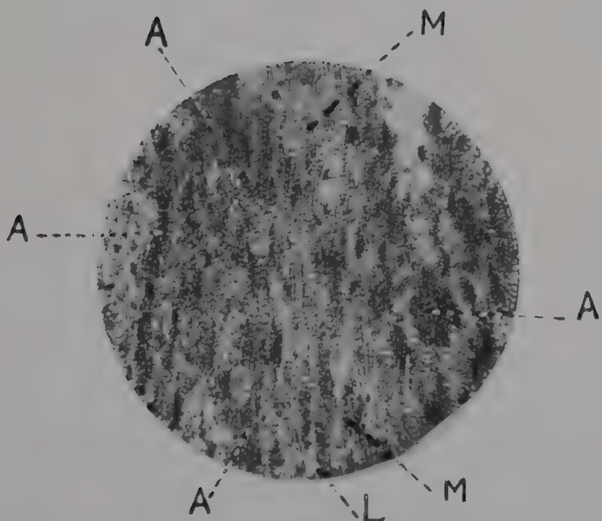
B. Longitudinal section Brown Bast cortex. C is the innermost layer of cortex overlying the cambium. L, L[1], etc., are latex vessels. Note displacement (and irregularity as compared with **A**) due to new tissue formation M. × about 60.

PLATE 20.

A.



B.



A. Tangential section normal cortex. Note the regular network of cylinder of latex vessels L, medullary rays M. × about 40.

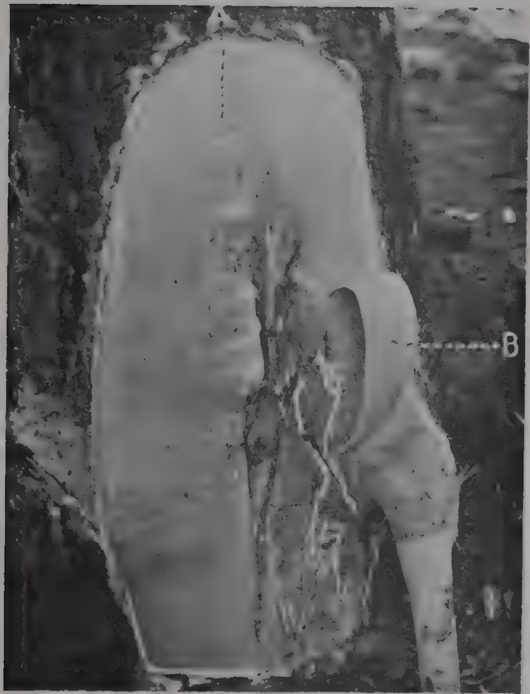
B. Tangential section Brown Bast cortex.

Note the points A where the new tissue has broken the regularity of the network of latex vessels L. At some points M (medullary rays) and L (latex vessels), the net work is still intact. × about 40.

Compare with **A.**

PLATE 21.

A.



A. Portion of Brown Bast cortex in process of stripping. A indicates positions of underlying wood showing the commencement of irregular crevices due to new tissue formation near the inner surface of the cortex and a consequent retardation of new tissue formation from the cambium at these points.

The diseased cortex in this case was removed in strips (B), thus facilitating the operation and saving time.

B. Operation as **A** completed, and the surface being sprayed with melted paraffin wax. Note the simple apparatus for melting wax and the common garden syringe used for spraying.

B.

PLATE 22.

A.

B.

Photograph of trees stripped because of Brown Bast.

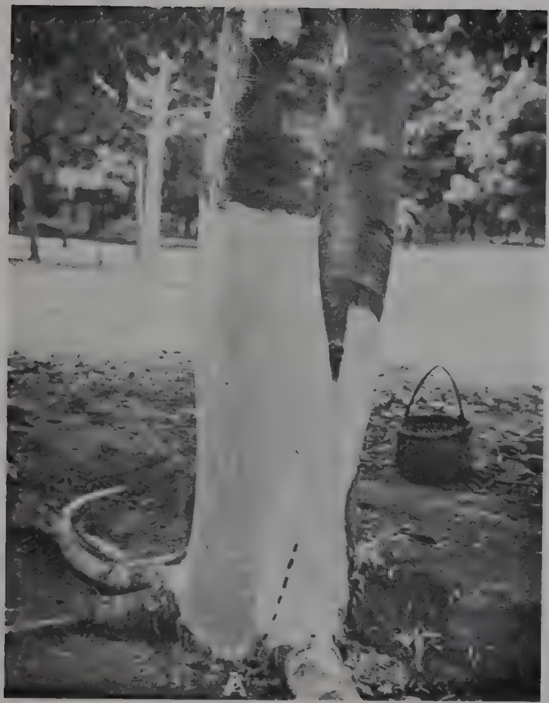
A. Stripped all round 2 feet to 4 feet above ground. Portions of laterals also stripped.

Fifteen months after stripping, regenerated cortex 4-5 mm. in thickness.

B. Stripped $2\frac{1}{2}$ feet high half way round.

Laterals and tap root also partially stripped.

PLATE 23.



A combination method of treatment—scraping and stripping.

The whole of the affected cortex was first well scraped and presumably by this means the diseased tissue removed from the whole area except at A where it was found to be too deep seated for scraping to be safely carried out.

The portion A was therefore stripped and the whole area afterwards sprayed with paraffin wax.

PLATE 24.

Five years old tree stripped for Brown Bast after being in tapping five months.

PLATE 25.

Nine years old tree stripped for Brown Bast and continued in tapping

PLATE 26.

Regenerated cortex in stripped tree (Brown Bast) brought into tapping after $2\frac{3}{4}$ years.

Yield normal as compared with neighbouring trees of same age. The black band is a method of controlling bark consumption.